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PATENT APPLICATION NO: PI 2003 2400

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CERTIFICATE OF FILING

APPLICANT	:	NEURAMATIX SDN. BHD.
APPLICATION NO	:	PI 20032400
REQUEST RECEIVED ON	:	26/06/2003
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AGENT'S/APPLICANT'S FILE REF.	:	20303178/ATMD/WCL/CT/GM

Please find attached, a copy of the Request Form relating to the above application, with the filing date and application number marked thereon in accordance with Regulation 25(1).

Date : 15/07/2003

(MOHD. AMRAN ABAS)
for Registrar of Patents

To : LINDA WANG CHAW LING
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Patents Form No. 1

PATENTS ACT 1983

REQUEST FOR GRANT OF PATENT
(Regulation 7(1))

To: The Registrar of Patents
Patent Registration Office
Kuala Lumpur
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For Official Use

APPLICATION NO: PI 20032400

APPLICATION RECEIVED ON: 26-06-2003

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Agent's file reference

20303178/ATMD/G/WCL/CT/gm

THE APPLICANT(S) REQUEST(S) THE GRANT OF A PATENT IN RESPECT OF THE FOLLOWING PARTICULAR:

I. TITLE OF INVENTION: **NEURAL NETWORKS WITH LEARNING AND EXPRESSION CAPABILITY**

II. APPLICANT(S) (the data concerning each applicant must appear in this box or, if the space is insufficient, in the space below)

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26 JUN 2003

Harta Intelek Malaysia

20032400

III. Inventor

Applicant is the inventor Yes [ ] No [X]

If the applicant is not the inventor :

Name of inventor : **HERCUS, Robert George**

Address of inventor : **142, Jalan Maarof, Bangsar**

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A statement justifying the applicant's right to the patent accompanies this Form :

Yes [X] No [ ]

Additional Information (if any)

IV. Agent or Representative

Applicant has appointed a patent agent in accompanying Form No. 17

Yes [ ]

No [ ]

Agent's Registration No. : **PA/99/0071**

Applicants have appointed .... to be thier common representative

V. Divisional Application

This application is a divisional application [ ]

The benefit of the

filing date [ ] priority date [ ]

of the initial application is claimed in as the subject-matter of the present application is contained in the initial application identified below :

Initial Application No. : ....

Date of filing of initial application : ....

VI. DISCLOSURES TO BE DISREGARD FOR PRIOR ART PURPOSES

Additional information is contained in supplemental box:

(a) Disclosure was due to acts of applicant or his predecessor in title ☐

Date of disclosure : ....

(b) Disclosure was due to abuse of rights of applicant or his predecessor in title ☐

Date of disclosure : ....

A statement specifying in more detail the facts concerning the disclosure accompanies this Form

Yes ☐

No ☐

Additional Information (if any)

VII. PRIORITY CLAIM (if any)

The priority of an earlier application is claimed as follows :

Country (if the earlier application is a regional or international application, indicate the office with which it is filed):

....

Filing Date : ....

Application Nos. : ....

Symbol of the international Patent Classification :

If not yet allocate, please tick ☐

The priority of more than one earlier application is claimed :

Yes ☐ No ☐

The certified copy of the earlier application(s) accompanies this Form :

Yes ☐ No ☐

If No, it will be furnished by upon request ....(date)

Additional Information (if any)

DITERIMA
26 JUN 2003
Unit Pusat Perbadanan Harta Intelek Malaysia

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VIII. CHECK LIST

A. This application contains the following:

1. request
2. description .... 26 sheets
3. claim .... 12 sheets
4. abstract .... 1 sheets
5. drawings .... 17 sheets

Total .... 56 sheets

A. This Form, as filed, is accompanied by the items cheeked below:

(a) signed Form No. 17	☐
(b) declaration that inventor does not wish to be named in the patent	☐
(c) statement justifying applicant's right to the patent	X
(d) statement that certain disclosures be disregarded	☐
(e) priority document (certified copy of earlier application)	☐
(f) cash, cheque, money order, banker's draft or postal order for the payment of application fee	X
(g) other documents (specify)	☐

IX. SIGNATURE

Linda Wang .... 26 June 2003

LINDA WANG

**~~(Applicant~~/Agent) (Date)

If Agent, indicate Agent's Registration No. : PA/99/0071

For Official Use

1. Date application received: ....
2. Date of receipt of correction, later filed papers or drawings completing the application:

....

Neural Networks with Learning and ExpressionCapability

Field of Invention

This invention relates to neural networks and particularly, though not exclusively, to neural networks based on one or more of temporal and spatial characteristics, and may be used for one or more of: learning, engaging in activities, knowledge acquisition and self expression.

Background to the Invention

Existing neural networks are typically based on a single interpretation of Hebbian learning. This basic, Hebbian concept is often stated as "Neurons that fire together wire together". The defacto interpretation is that "wiring together" is effected via the synapse that connects the two neurons together. The strength of the connecting synapse is modified or weighted to reflect the importance/probability of the presynaptic neuron firing concurrently with the postsynaptic neuron, or vice versa.

Using the concept, neural networks have been developed that link a number of input neurons to a number of output neurons via synapses. The input neurons define the input states; and the output neurons define the desired output states.

Thus nearly all existing neural networks are based on the concept of three layers: an input neuron layer, a hidden layer (the synapses), and an output neuron layer. Figures 1 and Figure 2 are illustrations of existing neural networks.

Training of such neural networks is accomplished by applying a specific input state to all the input neurons, selecting a specific output neuron to represent that input state, and adjusting the synaptic strengths or weights in the hidden layer. That is, training is conducted assuming knowledge of the desired output. After training has been completed, the application of different input states will result in different output neurons being activated with different levels of confidence. Thus recognition of an input event depends on how close the original training states match the current input state.

Such neural networks typically require extensive, repetitive training with hundreds or thousands of different input states, depending on the number of desired output neurons and the accuracy of the desired result. This results in practical networks of the order of only 10,000 input and output neurons (as compared to the capacity of the human brain of 10^{12} neurons) with as many as 10 million interconnecting synapses.

Furthermore, existing networks are trained on the basis of generating predefined output neurons, and can subsequently recognise inputs that closely resemble the training sets used for input. Existing neural networks are not capable of independent learning as they are trained using prior assumptions – the desired goal is represented by each output neuron. Existing neural networks are not capable of expressing or recollecting an input state based on the stimulus of any output neuron in the output layer.

Existing neural networks are trained on the basis of applying independent input states, to the network, in which the order of training is insignificant. On completion of extensive, repetitive training, the output neurons are not significantly dependent on the order in which input states are applied to the network. Existing neural networks provide outputs that are based entirely on the current input state. The order in which input states are applied has no bearing on the network's ability to recognise them.

Existing neural networks may have some or all of the following shortcomings:

1. They require prior training, based on desired output goals – they do not learn;
2. They can only recognise input states (objects) similar to the input states for which they have been trained;
3. They are highly computational, and therefore slow;
4. They can represent only a relatively small number of neurons;
6. They need retraining if they are to recognise different objects;
7. They cannot express or express an input object by applying a stimulus to output neurons;
8. They are based on concurrent stimuli of input neurons; that is, a single input state for each event; and

9. They are not creative and they cannot express or recollect events; they can only identify/recognise events for which they have been trained.

Summary of the Invention

In accordance with one aspect of the invention, there is provided a neural network comprising a plurality of neurons in which any one of the plurality of neurons is able to associate with another neuron in the plurality of neurons via active connections to a further neuron in the plurality of neurons.

In accordance with a second aspect of the invention there is provided a neural network comprising a plurality of elemental neurons, and a plurality of structural neurons for representing associations between any pair of neurons, the pair of neurons being selected from the group consisting of: both elemental neurons, both structural neurons, one structural and one elemental neuron, and one elemental neuron and one structural neuron.

The plurality of elemental neurons are represented in the root level of the neural structure, and each elemental neuron responds to an elemental stimulus or pattern, each elemental stimulus represents one of: a basic input stimuli and an output stimuli of information being processed, each elemental neuron being an equivalent of a neuron in a brain, the neuron in the brain being selected from the group consisting of: a sensor neuron and a motor neuron. The information may be memory, and the processing may be expression.

The plurality of structural neurons are represented in a plurality of deeper neural levels. The number of levels in the plurality of deeper levels may be determined by the extent of the memory or pattern to be processed or expressed, where a memory represents a plurality of elemental stimuli, where each elemental stimulus is represented directly by an elemental neuron. The number of elemental neurons required to represent the memory may be determined by the nature of the memory to be processed.

In accordance with a third aspect of the invention there is provided a neural network comprising a plurality of neurons linked by associations, all associations being able to be expressed.

A fourth aspect of the invention provides a neural network comprising a plurality of neurons, each neuron being represented by an addressable node in an array;

A fifth aspect of the invention provides a neural network comprising a plurality of neurons, each neuron being represented in its entirety by a single, fixed-length node in an array. The neural network is self-contained and self-sufficient and does not inherently require extra structures or data arrays to be able to operate.

A penultimate aspect of the invention provides a neural network comprising a plurality of neurons in an array, there being up pointers in the array for providing expression.

A final aspect of the invention provides a neural network comprising a plurality of neurons, each neuron being represented by a node in an array, each node having a plurality of pointers, each pointer in each node has a specific and unique function. Except where the pointer represents the value of an elemental stimulus in the elemental or root level neurons, each pointer contains an address of another neuron. The number of pointers may depend on the function being performed by the neural network. For a neural network performing recollection only, the minimum number of pointers for each neuron may be as low as two. For a neural network performing learning and recollection functions, the number of pointers needed will be at least four. The function of each pointer may be one of: initiating, associating, successor and next successor of the initiating neuron.

All neurons are of a fixed length and do not have a variable length.

The present invention also extends to a computer usable medium comprising a computer program code configured to cause one or more processors to execute one or more functions to perform the method described above.

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Description of the Drawings

In order that the invention may be readily understood and put into practical effect there shall now be described by way of non-limitative example only preferred embodiments of the present invention, the description being with reference to the accompanying illustrative drawings in which:

Figure 1 is an illustration of an existing neural network structure;

Figure 2 is a further illustration of an existing neural network structure;

Figure 3 is an illustration of an existing relationship between two neurons and a synapse;

Figure 4 is an illustration of the relationship between three neurons according to the present invention;

Figure 5 is a flow chart of the process flow of the present invention;

Figure 6 is an illustration of the relationship between neurons and pointers/links;

Figure 7 is an illustration of a sequence of events to illustrate association;

Figure 8 is a flow chart for the matching of neurons;

Figure 9 is a flow chart for the setting of pointers;

Figure 10 is a flow chart for successor neurons; and

Figure 11 is a flow chart for expressing of neurons.

Description of Preferred Embodiments

According to a preferred aspect the present invention provides neural networks, and method for constructing such neural networks via neuron associations, that are based on one or both of the temporal and spatial characteristics for the formation of memories, that consist of one or both of either input stimuli (represented by elemental stimuli) or output actions (represented by elemental stimuli) in a natural manner.

It also provides for either or both of memory recollection and memory expression of one or more of the memories represented by structural neurons, which represent multiple elemental stimuli. The neural network allows for the expression of new actions or ideas other than what it was taught such that it may exhibit creativity. Input stimuli may include one or more of: audio, visual, tactile, and so forth. Output stimuli may include one or more of: movement, motion, speech, and so forth.

Existing neural networks are based on the assumption that concurrently activating two neurons (neurons B and C) creates an active synaptic connection between them, or strengthens an existing synaptic connection. This is illustrated in Figure 3 where there are two neurons and one synapse.

Accordingly to the present invention, stimulating two neurons creates an association between them via another third neuron, the associating neuron. This is illustrated in Figure 4 where there are three neurons 41, 42 and 43 and two synapses 44 and 45. This basic structure will be called a "neuronal network" or "memory" throughout this specification. Neurons 41, 42 and 43 may be linked together based on proximal characteristics, either temporal or spatial. Neuron 43 will be in a deeper level within the neural structure than both of neurons 41, 42. Neurons 41,42 may be in the same level, or may be in different levels of the neural structure. A neuron is in a deeper level within the neural structure if, during recollection, more steps are required to express the elemental neurons.

The neuronal structure comprises neurons, where each neuron represents a memory of events, objects, concepts or actions. The type of information represented by each neuron can vary, and is dependent on the elemental neurons (representing sensor and/or motor neuron stimuli) from which the neuronal network is constructed. Elemental stimuli are only represented in the elemental neurons maintained at the root level of the neural network structure. Deeper or subsequent level neurons only represent the association of other neurons and do not in themselves store sensor or elemental stimulus values values.

Each neuron in the neuronal structure may represent the association of only one initiating neuron and only one associated neuron, although each neuron may participate as an initiating neuron and/or as an associated neuron in an unlimited number of associations, via linking neurons. An initiating neuron 41 can have any number of successor neurons such as neuron 43, where a successor neuron is a linking neuron (43) that has neuron 41 as its initiating neuron. Another neuron 42 can have any number of precessor neurons, where a precessor neuron is a linking neuron that has neuron 43 as its associated neuron. Thus, neuron 43 can be referred to as an

associating neuron, or a successor neuron to neuron 41, or as a precessor neuron to neuron 42. A precessor neuron is an initiating neuron of an association.

The sequence of events is that one of the elemental neurons 41, 42 is an initiating neuron and on is an associated neuron. Assuming neuron 41 is the initiating neuron and thus neuron 42 is the associated neuron, when initiating neuron 41 fires linking neuron 43 is potentiated. At the same time as, or subsequent to, neuron 41 firing associated neuron 42 fires and also potentiates linking neuron 43. Neuron 43 is then considered activated and may fire when reactivated. The proximal firing of neurons 41 and 42 causes the activation of linking neuron 43, and the creation of connections, or the strengthening of existing synaptic connections, between neurons 41 and 43 and neurons 42 and 43. Linking neuron represents the sum of what is learnt from the other two neurons 41, 42. This sum may include one or more of a memory trace, a combination of the experience of the two, a sequence of events, and so forth. Once a linking neuron is activated or created to represent a desired result, the desired result need not be recreated in another neuron.

The definition of proximity or proximal firing will be set by the rules of operation for the neuronal network. Proximity ("ΔP") may vary across a level, and across levels, and may vary according to the type of elemental neuron being represented. Neurons at deeper levels within the neural network are less likely to be in close proximity, thus it is likely that ΔP will increase. As ΔP represents time or temporal events may be as short as zero, milliseconds or seconds, or as long as minutes, hours, days or weeks. It may also vary according to the processing requirements of the memories or events being represented by the neural structure.

The neuronal network illustrated in Figure 4 consists of two basic elements.

1. Elemental neurons, which can represent either sensor or motor neurons. These are the elemental or root neurons from which the neuronal network is constructed. Different types of elemental neurons may be defined depending on the type of experience or events or information being represented. For example if representing the auditory cortex the elemental neurons would be for representing sounds. The elemental neurons may incorporate a number of

different types of elemental neurons such as, for example, one set for representing sound energy or intensity of the sound (volume), and another set for representing the frequency of the sound.

If representing smell and taste there may be a set of elemental neurons for taste and another set for olfactory sensing.

In vision there may be sets of elemental neurons to represent the colour cones, rods, edges, contrast, movement, and so forth, as represented by the ganglion cells, or specifically to represent the photoreceptor neurons.

For skin receptors there may be elemental neurons corresponding to touch – mechanoreceptor neurons; temperature – thermo receptor neurons; pain – nociceptor neurons; and so forth. Motion can be represented by the various types of motor neurons that induce movement.

When a sensory neuron fires, it communicates to different areas of the brain via synapses or nerve cells that a certain form of energy from a specific cell or sensory organ at a specific location has been received. All sensory neurons have similar central processing mechanisms. When a motor neuron is fired in the brain it induces muscle contraction at a specific location in the body thus producing movement. When a sensory neuron detects an event it passes the data to the brain where it is processed in the brain's neural structure.

Artificial elemental neurons may also be defined. For example, if using the neuronal structure to process English text, a set of elemental neurons may be defined to represent the alphabetic characters and punctuation characters. For the Chinese language, elemental neurons could be defined for each Chinese character, or a subset thereof. If using the neuronal structure to process protein sequences, the elemental neurons may be defined to represent the twenty amino acids, or subsets thereof. For speech different motor neurons may be defined to produce different muscular contractions resulting in the production of sounds corresponding to phonemes, and so forth.

Elemental neurons can be initiating and associating neurons but cannot be a linking neuron.

2. Structural neurons representing the neuronal structure.

The neuronal structure as illustrated in Figure 4 consists of neurons that represent the association of other neurons, whether they be sensor neurons, motor neurons, or other structural neurons. In this manner neuronal structures can grow, representing more and more information.

Structural neurons can also be used to form associations between structural neurons representing different sensory organs. For example, an association may be formed between the English word "ball" represented by an association of alphabetic elemental neurons, with the shape "ball" represented by an association of visual elemental neurons. In this manner it is possible build neuronal networks which allow the association of information across different cortexes. Another association between the shape "ball" may exist with the spoken word "ball" represented by an association of motor neurons to enable phoneme neurons to produce the sound "ball".

Structural neurons are associated with each other on the basis of temporal or spatial characteristics. If representing speech with the neuronal structure, the associations would be of a temporal nature, representing the sequence of phonemes, words, phrases, clauses, and so forth, used in expressing speech. Likewise, if processing text or reading a book the processing of individual characters would be of a temporal nature building up the words, phrases, clauses, and so forth. Many neurons in the brain are also organised spatially or topographically, such as those for vision, hearing, touch, pain, and so forth. As such it is possible to construct neuronal structures that represent spatial characteristics. For example, in forming a neuronal structure representing a visual scene, neurons representing objects or patterns may be associated into a neuronal structure that associates near objects with far objects, or high objects with low objects, thus building a three dimensional map of the environment.

The same neuronal structure can be used to represent information in any of the four dimensions defined by space and time.

As above, the shape "ball" – represented by a spatial neuronal structure - may be associated with the spoken word "ball" represented by a temporal neuronal structure.

Structural neurons can be an initiating neuron, and associating neuron and a linking neuron, and all possible permutations and combinations of them.

The combination of elemental neurons at the root levels of association within the neuronal structure allows for the creation of structural neurons that represent particular elemental features or characteristics within a cortex (often referred to as perceptrons). The neuronal coding structure allows for the representation of feature combinations by dynamic association within the neuronal structure. Neuronal activity in the neocortex that is evoked by sensory neurons is always distributed in the brain to different areas. In sensory systems, different areas of the brain can process different aspects (spatial/temporal) of the same input stimuli. The proposed neuronal structure allows for intra-areal neuronal associations in order to represent coherent concepts/percepts and behaviour. Deeper levels of association within the neuronal structure (intra cortico-cortical associations) allows for the representation of increasingly complex information or behaviour.

Neurons may be organised, classified or named according to their functions, characteristics, levels, nature, and so forth. For example: there may be elemental neurons, initiating neurons, etc. Neurons may also be defined for a particular dimension. That dimension may be time, distance, space, length, height, pitch, amplitude, or any other definable characteristic.

Within its particular dimension, any two neurons may be differentiated according to their relative scale or magnitude. This difference is represented by ΔP. For example, if the dimension was defined as frequency, then ΔP could represent the relative frequency between two neurons.

The basic underlying parameter for constructing a neuronal network is that for any two active neurons A followed by B there exists a third neuron C that has connections via synapses to both A and B. Therefore neuron C links neurons A and B together in that order. A and B may be, but do not have to be, contiguous or consecutive. Therefore neuron C can link any two neurons A and B which represent events whether the events are contiguous, consecutive, non-contiguous, non-consecutive or overlapping. Event B cannot preceed event A.

The logic of the association is that for any two active neurons A and B, one of them will be an initiating neuron. The third neuron C will associate the initiating neuron with the second neuron in that order. In other words, neuron C represents the combined events of the initiating neuronal event followed by the second neuronal event. This new neuron C can subsequently participate in combining with other neurons (thus creating new associations), and so forth.

The basic rule for creating new neurons is that if neuron A is activated or fired, followed by neuron B being activated or fired, then a new neuron C can be constructed representing the association of neurons A and B (i.e. the sequence of events AB in time or space). If C already exists due to a prior event or association then neuron C can likewise be re-activated and fired, as well as participating in subsequent existing or new activations, thereby allowing it to participate in new associations. This allows for the construction of neural networks with an unlimited numbers of associations and/or relationships. The interval between the activation of one neuron and another is Δd. Δd is used to indicate the dimensional characteristic (either temporal or spatial) that is used as a basis for associating two neurons together, via a third neuron.

A flowchart representing the basic flow of this new neural network is shown in Figure 5.

In Figure 5, the neural network is initialized at 50. At 51 the type or category of each elemental neuron is defined. The elemental neurons will represent event sequences. The event sequences may be related to, for example, text, vision pitch, colour, edge, sound, volume, taste, olfactory sensing, colour cones, rods, pain, contrast, movement, muscular movement, ganglion cells, photoreceptors, touch, mechanoreceptors,

temperature, thermo-receptor, nociceptor, motion, language, characters, letters, words, and so forth.

The elemental neurons are then defined/programmed/input at 52. The question is then asked: does the elemental neuron already exist? (53). For each unique value to be represented for each defined type of defined elemental neuron, all elemental neurons must be created, and are attached to the root neuron. If the answer to the query is no, a new elemental neuron is created (54) and the process returns to (52). If yes, the process continues to 55. Here, the rule to associate the neurons is defined.

The first, or next initiating, neuron is then found(56). This is designated neuron A. The subsequent neuron (neuron B) is then found (57). If an association of A + B exists (58), the process reverts back to 56. If not, a neuron C is created as a combination of A + B (59) and the process reverts back to 56.

Upon reverting back to 56, the next initiating neuron will then become other than A.

Figure 8 is a flow chart providing more detail of steps 56 to 59 of Figure 5. Here, neuronal processing or learning is of an experience represented by a pattern or sequence of elemental neuron events.

In step 81, the event pointer is set to the first elementary event in the event pattern or sequence. An optimal matching neuron is found in step 82. The optimal matching neuron is for the event or events in the pattern or sequence of events pointed to by the event pointer. This matching neuron is defined as the initiating neuron (neuron A).

Another optimal matching neuron is then found in step 83. Again, this neuron is for the event or events in the pattern or sequence of events pointed to by the event pointer. This another matching neuron is defined as the associated neuron (neuron B).

A further neuron that has not been used is then found in step 84. This is created as the linking neuron (neuron C) in step 85. The process of steps 82 to 85 are repeated in 86 until there are no more events in the pattern or sequence of events being processed.

Figure 9 provides more detail of the process steps 82 and 83 of Figure 8 – the finding of an optimal matching neuron.

In step 91 the matching neuron pointer is set to zero. For each successor neuron of the matching neuron (step 91), a check is conducted to determine if expression of the successor neuron matches the next event or sequence in the pattern or sequence of events. If it does, the process moves to step 93 where the pointer for the matching neuron is set to point to the successor neuron that matches the event pattern or sequence. In addition, the event pointer is adjusted to point to the remainder of the patter or sequence of events that, as yet, have not been matched. The process then reverts to step 92 and continues. If the result of step 93 is that it doesn't match, in step 94 the matching neuron pointer is returned to the state it was in before step 91, and the process ends in step 95.

Figure 10 illustrates in more detail the process of step 85 in Figure 8 – the creation of a linking neuron. In step 101, the initiating pointer of the linking neuron is set to the initiating neuron, and in step 102 the associated neuron pointer of the linking neuron is set to the associated neuron. As the linking neuron has no successor neurons, its successor neuron pointer is set to zero (step 103). The next neuron pointer of the linking neuron is then set to be equal to the successor neuron pointer of the initiating neuron. In this way the linking neuron becomes the first successor neuron of the initiating neuron (step 104). Finally, in step 105, the successor pointer of the initiating neuron is set to point to the linking neuron and thus the linking neuron becomes the first entry in the list of successor neurons to the initiating neuron.

A group of elemental neurons representing a common characteristic may be organised into a cortex. Thus, it is possible to have a visual cortex containing groups of neurons which relate to a first visual characteristic (for example, a group of neurons for colour); a second group for second visual characteristic (for example, shape); a third group for a third visual characteristic (for example, size), and so forth. Multiple cortexes (and the neurons within them) can be interlinked and related to form an integrated 'brain' which can provide not only an integrated learning environment, but also the potential for intelligent behaviour.

Traditional neural networks are typically unidirectional. This means that, given a certain input the output can be derived. However, they cannot work in the reverse direction. That is, given the output, it is not possible to derive the input.

By providing for the capability for 'expression', the sequence of events that leads to the construction of any neuron can be expressed. The importance of expression is that it allows a complete sequence of events to be represented by a single neuron, and that sequence can be reproduced by activating that single neuron and, in turn, the neurons that represent the association, and so forth. In this manner it is possible for a single neuron representing a complete experience (sequence of events) to be expressed.

The expression ability is implemented by way of having up pointers in the neuronal structure.

Expression is illustrated in Figure 11. When expression is required, the first check in step 111 is to determine if the initiating pointer of the neuron to be expressed is equal to zero. If yes, it must be an elemental neuron and the process reverts to step 114 where expression is activation of the element event or value stored in the associated neuron pointer. If the value is not zero, step 112 is started. In step 112 is expression of the neuron pointed to by the initiating neuron pointer of the neuron to be expressed. In step 113 is expression of the neuron pointed to by the associated neuron pointer of the neuron to be expressed. This continues until the check in step 111 is "yes".

Each neuron in the network may have an address to identify its location. All the addresses will be stored in an address table. The size of the address table will influence the number of neurons in the network. For example: using an address table size of 32 bits will allow the construction of temporal neural networks consisting of 2^{32} or 4,294,967,296 neurons.

Each neuron is represented by a single fixed length node in a conventional array or structure. The number of neurons that may be stored in an array will be dependent on the total memory storage available (internal and/or external), and on the address architecture:

A 16 bit address architecture will allow for up to 2^{16} neurons. This is 6.4×10^3 neurons;

A 32 bit address architecture will allow for up to 2^{32} neurons. This is 4.1×10^9 neurons;

A 48 bit address architecture will allow for up to 2^{48} neurons. This is 2.7×10^{14} neurons;

A 64 bit address architecture will allow for up to 2^{64} neurons. This is 1.8×10^{19} neurons.

As the human brain has approximately 10^{12} neurons, it may be possible match the capacity of a hundred human brains using a 48 bit address architecture. Based on the latest computers that support 64 bit addressing, it may be possible to have the capacity to represent neural structures consisting of 10^{19} neurons, the equivalent size of 10 million human brains wired together.

To represent the neural network, a node will consist of a minimum of four pointers. Each pointer contains an address to another neuron. As explained above, using a address size of 32 bits will allow the construction of temporal neural networks consisting of up to 2^{32}, or 4 billion, neurons. The maximum memory requirement for such a neural network would be only 64 Gigabytes of memory. This is derived from 4 billion nodes x 4 pointers each x 4 bytes each (32 bits) which can realistically be implemented in present computer systems such as those having a 64-bit "Itanium" chip.

As shown in Figure 6, each neuron is represented by four pointers/links (P_1, P_2, P_3 and P_4), in its most basic implementation. Each pointer is a link to the address or location of another neuron. Typically, a neuron will have four pointers, the minimum needed to create an intelligent neural network with expression capabilities. However, a neuron may have more than four pointers, to provide additional functionality.

P1 – A pointer to the initiating neuron, i.e. neuron A.

P2 – A pointer to the other neuron that participates in forming the association, i.e. neuron B.

P3 – A pointer to a list (LC) of deeper level neurons that has neuron C as an initiating neuron.

P4 – A pointer to the next neuron in a different list (LA) that has neuron A as its initiating prior neuron.

Subsequent neurons represent associations that occur between these or any other neurons.

Deeper level neurons may represent complex sequences of events. Since each neuron has at least one prior neuron, and one successor neuron, a single neuron at level 10 may represent a sequence of up to 2^{10} or 1,024 events. It is not a necessary condition that neurons can only link with neurons of the same level.

Thus, in storing new sequences of events it is only necessary to identify those existing neurons which represent existing event sequences in the event stream and associate these together by constructing new neurons, e.g. if we have two event sequences of say 1,024 events and 512 events, respectively, it is possible to construct a single, new neuron to represent an event sequence of 1,536 events. Thus new sequence/event information can be economically represented in the temporal neural network.

This is illustrated in Figure 7. Figure 7 is an illustration of text reading (or voice recognition) for the sentence; "The cat sat on the mat." An arrowed line indicates the connection between an initiating neuron and a linking neuron, and a circled line indicates a connection between the associated neuron and the linking neuron.

In Figure 7(a), the first elemental neuron 701 and the second elemental neuron 702 in level zero recognise or represent the letters "T" and "H" and associate to form the letter combination "TH" represented by the linking neuron 711 in level 1.

Figure 7(b) shows the third elemental neuron 703 recognising the letter "E" and the fourth elemental neuron 704 recognising the space "^". These two link together to form the combination "E^" represented by linking neuron 712 in level 1.

The structural neurons 711 and 712 in level 1 associate to form the distinct word "THE^" represented by the linking neuron 721.

In Figure 7(c), (d) and (e), the next two elemental neurons in level zero – 705 and 706 – recognise the letters "C" and "A" respectively, and associate to form the letter combination "CA" represented by linking neuron 713 in level 1.

For the letters "T" and "^", neuron 701 associates with neuron 704 to create a linking neuron 714 in level 1 representing the combination "T^". Neurons 714 and 713 then associate to create a linking neuron 722 in level 2 thus forming the distinct word "CAT^" (Figure 7(e)). Neurons 721 and 722 can then associate to give a result at the linking neuron 731 in level 3 to form the phrase "THE^ CAT^" (Figures 7(f) and 7(g)).

For the word "SAT^", as is shown in Figures 7(h), neuron 707 recognises the letter "S" and associates with neuron 706 to give a result at linking neuron 715 in level 1 for the letter combination "SA". Neuron 715 associates with neuron 714 in level 1 ("T^") to give a result at linking neuron 723 in level 2 for the distinct word "SAT^".

In Figures 7(i) and 7(j), neurons 708 and 708 recognise the letters "O" and "N" respectively and associate to form the letter combination (and word) "ON" represented by linking neuron 716 in level 1. Neuron 716 associates with neuron 704 to give a result at linking neuron 724 in level 2 for the distinct word "ON^". Neuron 724 in level 2 associates with neuron 723 to give a result at linking neuron 732 in level 3 for the clause "SAT^ON". Neurons 731 and 732 in level 3 associate to give a result at neuron 741 in level 4 for the clause "THE^CAT^SAT^ON^
".

Figures 7(k) and (l) illustrate neuron 7010 recognising the letter "M" and associating with neuron 706 to give a result at neuron 717 in level 1 for the letter combination "MA". Neuron 717 associates with neuron 712 ("T^") to give a result at neuron 725 for the distinct word "MAT^". Neuron 725 associates with neuron 721 ("THE^) to give a result at neuron 733 for the phrase "THE^MAT^".

Neurons 741 and 742 can associate to give a result at neuron 751 in level 5 for the sentence "THE^CAT^SAT^ON^THE^MAT". It is clear that each linking neuron has at most one initiating neuron and one associated neuron. However, neurons can have

multiple successor and precessor neurons. For example elemental neuron 701 "T" has successor neurons representing "TH" (711) and representing "T^"(714). Elemental neuron 706 "A" has three precessor neurons representing "CA"(713), "SA" (715) and "MA"(717).

To extend the sentence is illustrated in Figure 7(m) where the neuron 7011 in level 0 recognises the letter "D". Neuron 7011 associates with neuron 704 to give a result at neuron 719 for the combination "D^" Neuron 719 associates with neuron to give a result at neuron 726 in level 2 for the word "AND". Neuron 726 associates with neuron ?? to give a result at neuron 734 in level 3 for the distinct word "AND^". When neuron 734 is associated with neuron 733, a result is created at neuron 742 for the phrase "THE^MAT^AND^".

In Figure 7(o) it shows that in level 0 each neuron represents only 1 letter/character. Each neuron in level 1 represents an association of 2 letters/characters; in level 2 each neuron represents an association of 4 letters/characters; in level 3 it s 8 letters characters; 16 letters/characters in level 4; 32 letters/characters in level 5; and so forth in multiples of 2 until each neuron in level 10 could represent the association of up to 1,024 letters/characters; and each neuron in level 20 could represent the association of up to 1,048,576 characters.

As can be seen, for text recognition the number of elemental neurons required is quite limited. One elemental neuron would be required for each of:

1. the 26 letters of the alphabet upper case;
2. the 26 letters of the alphabet lower case;
3. the 10 numbers;
4. the 32 punctuation and similar characters on the standard alphanumeric keyboard;
5. any other special characters (e.g. from the Greek alphabet) that may be required.

The number of structural neurons required and the number of levels of structured neurons can grow in consequence of use of the neural network. Using the example of text recognition, the number of documents concerned, the size of the learning event(s)

concerned, the use of language in the documents, and the maximum possible number of words, phrases, clauses, sentences, paragraphs, chapters, books, and so forth. By way of example, if all the plays of William Shakespeare were recorded using the present invention in text recognition, after the first play was recorded there would be a certain number of structural neurons "N1". When the second play was recorded, the neurons required would not be the simple arithmetic sum of those required for the independent processing of each of the plays. Only the extra neurons required to process the second play above and beyond those created for the first play would be added to N1 to give the enlarged total N2. Neurons for any previously existing letters, words, phrases, clauses, sentences (and so forth) would not be added, but their new associations would be added. Upon the third play being recorded, the extra neurons required would be added in the same way to give N3. The increase in the number of new neurons required would be less than to arrive at N2. That is, $N2 - N1 > N3 - N2$.

By the time the final play was entered, the increase in the number of neurons required would not be great. The main increase would be at lower levels in the neuron structure where new associations would be added. The lowest level would be a single neuron having all associations required for all plays.

As each neuron in each level can associate with any other neuron in any level to give a result at a third neuron, the number of potential permutation and combinations available is very large.

From a consideration of Figure 7, there are different combinations and paths that may be used to provide the result at neuron 751 "THE^CAT^SAT^ON^THE^MAT". As there are different possibilities there may be duplication at levels other than level 0. For example, in level 1 as illustrated the following combinations are recorded:
"TH", "E^", "CA", "T^", "SA", "ON", and "MA".
Other combinations are possible. For example:
"TH", "HE", "E^", "CA", "AT", "T^", "ON", "N^", and "MA".

This can be followed by a further range of possible combinations in level 2. By adopting rules to reduce or eliminate duplication, efficiency may be enhanced.

If a level 10 neuron is considered, it is capable of representing a sequence of up to 1,024 elementary events. The first element can be expressed by following the pointers up to the elemental or root level. This allows a relatively speedy expression.

Elemental neurons may be frequently activated both for storage and during express. In a pure binary implementation two elemental neurons or root level neurons can activate a single level 1 neuron. Two level 1 neurons could activate a level 2 neuron and so forth. If a sequence of 1,024 elemental events is activated and stored/expressed the following are processed:

1,024	level 0
512	level 1
256	level 2
128	level 3
64	level 4
32	level 5
16	level 6
8	level 7
4	level 8
2	level 9
1	level 10

representing the entire sequence of elementary events.

If the basic time between neurons firing was 1 millisecond, at the root level, a level 10 neuron would only fire (be reactivated) once every second. This is if the temporal neural structure is represented as a sequence of memory blocks/areas. Deeper level neurons could be stored in slower storage without impacting performance of storage and expression.

In the preferred neuronal network structure, elemental neurons have as their initiating neuron the root neuron for the neuronal network structure. This allows an unlimited number of elemental neurons to be created on the fly, rather than having to predefine elemental neurons. Alternatively, elemental neurons can be allocated a predetermined neuronal storage area in the neuronal structure, and each elemental neuron can then

be directly addressed (e.g. for ASCII text characters 8 bits), 256 elemental neuron addresses can be pre-allocated (0 to 255) and the address of the first associating neuron will be at address 256. Similarly for Unicode characters (16bits) 2^{16} elemental addresses can be pre-allocated, and the first associating neuron in the neuronal structure will start at address 2^{16}.

In the preferred mode, new elemental neurons can be added at anytime, anywhere in the neuronal structure, providing for complete flexibility. When using a predefined area for the elemental neurons, processing may be faster as there is no need to search a list of successors attached to the root neuron.

Elemental neurons may be represented with their initiating neuron pointer set to zero - pointing to the root neuron (whether it exists or not), and their associated neuron pointer set to the value of the elemental event to be represented by that elemental neuron. A elemental neuron can always be determined or identified easily as its initiating neuron value is always zero. Therefore, when expressing an elemental neuron, the system knows it has arrived at an elemental neuron because the initiating neuron value is zero.

In the preferred mode, new successor neurons to an initiating neuron are simply added to the front of the list. Therefore, they are attached directly to the initiating neuron. In this way recent memory traces are readily expressed..

However, various options are available to maintain lists of successor neurons. The neuronal structure allows this feature to be used in any manner the user chooses in order to provide added functionality to the neuronal architecture. For example, new linking neurons could be added to the end of the list, or the list could be maintained in numerical order, alphabetical order, and so forth. Likewise, neurons which are frequently accessed could be moved towards the front of the list, or at the front of the list, such that more recently activated memories are always more accessible. This also means that older memories are at the end of the list and less likely to experience expression.

In this manner the order of the list can be used to represent the relative synaptic strengths or activation levels of the successor neurons to an initiating neuron without having to use weights to represent the strength of synaptic connections.

The memory represented by any neuron can be expressed by simply expressing the initiating neuron pointer and then the expressing the associated neuron pointer. If the initiating pointer is zero, it is possible to express the elemental value contained in the associated neuron pointer. Otherwise, the process can be repeated for the initiating pointer - express its initiating neuron pointer and its associated neuron pointer, and so forth. Thus, any neuron can be fully expressed by expressing its parts in order.

It is possible to create neuronal network structures representing knowledge learnt. For example, if the following sentences of text are input:-

LUCY^IS^CRYING^UNDER^THE^TABLE^.
JOHN^IS^PLAYING^IN^THE^PARK^.
PETER^IS^READING^IN^THE^CHAIR^.
MARY^IS^SLEEPING^UNDER^THE^TREE^.
JOHN^IS^RUNNING^IN^THE^RACE^.
PETER^IS^PLAYING^ON^THE^SWING^.
MARY^IS^TALKING^ON^THE^PHONE^,

it is possible create neurons that represent the following clauses or memories:
IS CRYING
IS RUNNING
IS READING
IS SLEEPING
IS PLAYING
IS TALKING

In this case "IS^" has six new successor neurons.
Similarly it is possible to create the following phrases or memories.
UNDER THE TABLE
UNDER THE TREE

IN THE PARK
IN THE CHAIR
IN THE RACE

ON THE SWING
ON THE PHONE

Thus LUCY is associated with IS CRYING, but IS is associated with six different actions. By changing the expression of alternative successor neurons for IS, it is possible to express up to six phrases:

LUCY IS CRYING
LUCY IS RUNNING
LUCY IS READING
LUCY IS SLEEPING
LUCY IS PLAYING
LUCY IS TALKING

Although only the first phrase was ever learnt, or input to the neuronal network, it is possible to do the same for JOHN,PETER and MARY.

Effectively it is possible to generate new expressions based on the structure ** IS.and IS **.That is:

LUCY IS	IS CRYING
JOHN IS	IS RUNNING
MARY IS	IS READING
LUCY IS	IS SLEEPING
PETER IS	IS PLAYING
	IS TALKING

Therefore, it is possible to create or express 30 (5x6) phrases/clauses that are all syntactically correct, and are also all semantically correct. Similarly:

ON THE	THE TABLE

IN THE	THE PARK
UNDER THE	THE CHAIR
	THE TREE
	THE RACE
	THE SWING
	THE PHONE

which provides for the possibility of generating 21 phrases/clauses of this nature (3x7) which are all syntactically correct, but not all semantically correct.

Combining the two sets together gives the structure:
{*} IS {*} (*) THE {*}.

This provides for the expression of {5} IS {6} * {3} THE {7}, or 5x6x3x7 = 630 possible expressions, having learnt only seven input sentences. Thus the neuronal model allows the learning and building a neuronal structure of memories, and also allows the combining of those neurons or memories into new expressions or behaviour. The brain can explore new concepts or suggestions that are syntatically possible with what has previously been experienced. With millions of neurons, it is possible to express billions of syntactically correct sentences. That is, the neuronal network structure provides an ideal method for creative expression.

By use of a neuronal network is described above, it is possible to have a system that:

- is able to learn;
- has expression capabilities;
- stores associations rather than data;
- has an efficient usage of computer memory and storage space; and
- is computationally efficient.

Thus the network is able to recognise patterns within patterns of associations. As such it may be of use in varying industries such as, for example, monitoring and predicting stock price movements, internet surveillance, security, computer virus detection, phrases in speech and text, clauses in speech and text, plagiarism detection, data compression, and so forth.

The neural network and processes described above may be implemented in software or hardware. If in hardware, there may be part of a chip, all of a dedicated chip, or an array of chips, all being elemental neurons. Structural neurons may be in part of the chip containing the elemental neurons, or may be in an array of dedicated neurons. As all neurons exist, upon the first pass of data the first elemental neuron will learn the first element of the data. For example, the upper case letter "T" in the example used in Figure 7. The next elemental neuron would learn the next element of the data. Again using the example of Figure 7, the lower case letter "h". And so forth. As the elemental neurons and those in the higher levels of the neuronal network will be working more often to create the associations in the deeper levels, they will require faster processor speeds. Those in the deeper levels will be firing less often and therefore can have slower processor speeds.

The present invention also extends to a computer usable medium comprising a computer program code configured to cause one or more processors to execute one or more functions to perform the method described above.

Therefore, according to the present invention there is provided a neural network based on the concepts of neurons including sensor and motor neurons, and synaptic connections. Each neuron in the brain can be represented by a single node in an array in a natural manner. Neurons are fixed-length nodes in an array. Each synaptic connection can be represented by pointers to other neurons within each node. Neural nodes in the array consist solely and exclusively of pointers to other neurons in the data array. However, motor or sensor neurons contain a sensor value or motor value for interacting with the external environment. Each neuron contains connections to other neurons.

Elemental neurons, corresponding to sensory or motor neurons can be defined for interfacing to and interacting with external input.

The neural network can be represented and controlled based on the neurons and synaptic connections, with appropriate rules for creating the neural structure and traversing the neural connections. The network can learn by creating associations between neurons. For any neuron, its representation can be recalled and expressed,

and exploration of multiple associations, and permutations of its associations, with other neurons can be recalled or expressed. Neurons can represent memories, where a memory is defined as a neuron with connections.

Interfacing with or learning or processing an experience of external sensory neuron inputs and creating memories of input experiences is represented by neurons and by new connections between neurons.

Interfacing with or learning or representing an activity of external motor neuron inputs and creating memories of output actions is represented by new neurons and by new connections between neurons.

The neural network can learn, to recall or recollect memories, to interact or express itself with the external environment, and to think and to express itself creatively.

Whilst there has been described in the foregoing description preferred embodiments of the present invention, it will be understood by those skilled in the technology that many variations or modifications is details of design, construction or operation may be made without departing from the present invention.

The Claims:

1. A neural network comprising a plurality of neurons in which any one of the plurality of neurons is able to associate with another neuron in the plurality of neurons via active connections to a further neuron in the plurality of neurons.

2. A neural network as claimed in claim 1, where the further neuron is in a deeper level than both the neuron and the another neuron.

3. A neural network as claimed in claim 1 or claim 2, wherein the neuron and the another neuron are in the same level.

4. A neural network as claimed in claim 1 or claim 2, wherein the neuron and the another neuron are on different levels.

5. A neural network as claimed in any one of claims 1 to 4, wherein the plurality of neurons includes a plurality of elemental neurons and a plurality of structural neurons, all elemental and structural neurons being able to express the neurons with which they are associated.

6. A neural network as claimed in claim 5, wherein associations may be one or more selected from the group consisting of: an elemental neuron with an elemental neuron, an elemental neuron with a structural neuron, a structural neuron with an elemental neuron, a structural neuron with a structural neuron.

7. A neural network as claimed in any one of claims 1 to 6, wherein each of the plurality of neurons may be one or more selected from the group consisting of: initiating neuron, associating neuron, and linking neuron.

8. A neural network as claimed in claim 7, wherein an initiating neuron is associated with an associated neuron via active connections to the linking neuron.

9. A neural network as claimed in claim 8, wherein the initiating neuron, the associated neuron and the linking neuron are connected based on proximal characteristics.

10. A neural network as claimed in claim 9, wherein the proximal characteristics are at least one of: temporal and spatial.

11. A neural network as claimed in any one of claims 5 to 10, wherein a level of the neural network is a deeper level within the neural network structure if, during recollection, more steps are required to express the elemental neurons.

12. A neural network as claimed in any one of claims 1 to 6, wherein the one of the plurality of neurons is an initiating neuron, the another of the plurality of neurons is an associated neuron, and the further neuron is a linking neuron; the structure being such that when the initiating neuron fires, linking neuron is potentiated; and when associated neuron fires the linking neuron is re-potentiated and activated and may fire when reactivated.

13. A neural network as claimed in claim 12, wherein the associated neuron fires at the same time as the initiating neuron.

14. A neural network as claimed in claim 12, wherein the associated neuron fires after the initiating neuron.

15. A neural network as claimed in any one of claims 12 to 14, wherein the firing of the firing of the initiating neuron and the associated neuron is based on proximal characteristics.

16. A neural network as claimed in claim 15, wherein the proximal firing of the initiating neuron and the associated neuron causes the creation of new synaptic connections, or the strengthening of existing synaptic connections, between the initiating neuron and the linking neuron and between the associated neuron and the linking neurons.

17. A neural network as claimed in any one of claims 12 to 16, wherein the linking neuron represents the sum of what is learnt from the initiating neuron and the associated neuron.

18. A neural network as claimed in claim 17, wherein the sum includes one or more selected from the group consisting of: a memory trace, a combination of the experience of the initiating neuron and the associated neuron, a memory, and a sequence of events.

19. A neural network as claimed in any one of claims 12 to 18, wherein once the linking neuron is activated to represent a desired result, the desired result need not be recreated in another neuron.

20. A neural network comprising a plurality of elemental neurons, and a plurality of structural neurons for representing associations between any pair of neurons, the pair of neurons being selected from the group consisting of: both elemental neurons, both structural neurons, one structural and one elemental neuron, and one elemental neuron and one structural neuron.

21. A neural network as claimed in claim 20, wherein the plurality of elemental neurons are represented in a root level of the neural network, and each elemental neuron responds to an elemental stimulus or pattern, each elemental stimulus being for representing one of: a basic input stimuli and an output stimuli of information being processed.

22. A neural network as claimed in claim 20 or claim 21, wherein each elemental neuron is selected from the group consisting of: a sensor neuron and a motor neuron.

23. A neural network as claimed in claim 21, wherein the information is memory.

24. A neural network as claimed in any one of claims 20 to 23, wherein the processing is expression.

25. A neural network as claimed in any one of claims 20 to 24, wherein the plurality of structural neurons are represented in a plurality of deeper neural levels.

26. A neural network as claimed in claim 25, wherein the number of levels in the plurality of deeper levels is determined by the extent of the memory or pattern to be processed or expressed, where a memory represents a plurality of elemental stimuli, and each elemental stimulus is represented directly by an elemental neuron.

27. A neural network as claimed in claim 26, wherein the number of elemental neurons required to represent the memory is determined by a nature of the memory to be processed.

28. A neural network as claimed in any one of claims 20 to 27, wherein any one of the plurality of structural neurons is able to associate with another structural neuron in the plurality of neurons via active connections to a further structural neuron in the plurality of structural neurons.

29. A neural network as claimed in claim 28, where the further structural neuron is in a deeper level than both the structural neuron and the another structural neuron.

30. A neural network comprising a plurality of neurons linked by associations, all associations being able to be expressed.

31. A neural network as claimed in claim 30, wherein the plurality of neurons includes a plurality of elemental neurons and a plurality of structural neurons, all elemental and structural neurons being able to express the neurons with which they are associated.

32. A neural network comprising plurality of neurons, each neuron being represented by an addressable node in an array.

33. A neural network as claimed in claim 32, wherein each of the plurality of neurons is linked by associations, all associations being able to be expressed.

34. A neural network as claimed in claim 33, wherein the plurality of neurons includes a plurality of elemental neurons and a plurality of structural neurons, all elemental and structural neurons being able to express the neurons with which they are associated.

35. A neural network comprising a plurality of neurons, each neuron being represented in its entirety by a single, fixed-length node in an array.

36. A neural network as claimed in claim 35, wherein the neural network is self-contained and self-sufficient, not inherently requiring extra structures and data arrays to be able to operate.

37. A neural network as claimed in claim 35 or claim 36, wherein each of the plurality of neurons is linked by associations, all associations being able to be expressed.

38. A neural network as claimed in any one of claims 35 to 37, wherein the plurality of neurons includes a plurality of elemental neurons and a plurality of structural neurons, all elemental and structural neurons being able to express the neurons with which they are associated.

39. A neural network as claimed in any one of claims 35 to 38, wherein each of the plurality of neurons is represented by an addressable node in an array.

40. A neural network comprising a plurality of neurons in an array, there being pointers in the array for providing expression.

41. A neural network as claimed in claim 40, wherein each neuron is represented by a node in an array, each node having a plurality of pointers, each pointer in each node containing an exclusive address of another neuron.

42. A neural network comprising a plurality of neurons, each neuron being represented by a node in an array, each node having a plurality of pointers, each pointer in each node containing an exclusive address of another neuron.

43. A neural network as claimed in claim 42, wherein each pointer has a specific and unique function.

44. A neural network as claimed in claim 42 or claim 43, wherein the plurality of neurons includes a plurality of elemental neurons and a plurality of structural neurons, all elemental and structural neurons being able to express the neurons with which they are associated.

45. A neural network as claimed in claim 44, wherein except where the pointer represents the value of an elemental stimulus in the elemental neurons, each pointer contains an address of another neuron.

46. A neural network as claimed in any one of claims 42 to 45, wherein the number of pointers depends on a function being performed by the neural network.

47. A neural network as claimed in any one of claims 42 to 46, wherein the number of pointers for each neuron is in the range of two to at least four.

48. A neural network as claimed in any one of claims 43 to 47, wherein a function of each pointer may selected from the group consisting of: initiating, associating, successor and next successor of the initiating neuron.

49. A neural network as claimed in any one of claims 1 to 48, wherein all neurons are of a fixed length and do not have a variable length.

50. A neuronal structure for use in a neural network, the neuronal structure comprising an initiating neuron, an associated neuron, and a linking neuron operatively connected to the initiating neuron and the associated neuron.

51. A neuronal structure as claimed in claim 50, wherein when the initiating neuron fires, the linking neuron is potentiated; and when associated neuron fires the linking neuron is re-potentiated and activated and may fire when reactivated.

52. A neuronal structure as claimed in claim 51, wherein the associated neuron fires at the same time as the initiating neuron.

53. A neuronal structure as claimed in claim 51, wherein the associated neuron fires after the initiating neuron.

54. A neuronal structure as claimed in any one of claims 50 to 53, wherein the firing of the firing of the initiating neuron and the associated neuron is based on proximal characteristics.

55. A neuronal structure as claimed in claim 54, wherein the proximal firing of the initiating neuron and the associated neuron causes the creation of new synaptic connections, or the strengthening of existing synaptic connections, between the initiating neuron and the linking neuron and between the associated neuron and the linking neurons.

56. A neuronal structure as claimed in any one of claims 50 to 55, wherein the linking neuron represents the sum of what is learnt from the initiating neuron and the associated neuron.

57. A neuronal structure as claimed in claim 56, wherein the sum includes one or more selected from the group consisting of: a memory trace, a combination of the experience of the initiating neuron and the associated neuron, a memory, and a sequence of events.

58. A neuronal structure as claimed in any one of claims 50 to 57, wherein once the linking neuron is activated to represent a desired result, the desired result need not be recreated in another neuron.

59. A method from creating an association of neurons in a neural network, the neural network having a plurality of neurons, one of the plurality of neurons being an initiating neuron, another of the plurality of neurons being an associated neuron, and a further neuron of the plurality of neurons being a linking neuron; the method including:

(a) firing the initiating neuron to potentiate the linking neuron; and

(b) firing the associated neuron to re-potentiate and activate the linking neuron, the linking neuron being able to fire when reactivated.

60. A method as claimed in claim 59, wherein the associated neuron fires at the same time as the initiating neuron.

61. A method as claimed in claim 59, wherein the associated neuron fires after the initiating neuron.

62. A method as claimed in any one of claims 59 to 61, wherein the firing of the initiating neuron and the firing of the associated neuron is based on proximal characteristics.

63. A method as claimed in claim 62, wherein the proximal firing of the initiating neuron and the associated neuron causes the creation of new synaptic connections, or the strengthening of existing synaptic connections, between the initiating neuron and the linking neuron and between the associated neuron and the linking neuron.

64. A method as claimed in any one of claims 59 to 63, wherein the linking neuron represents the sum of what is learnt from the initiating neuron and the associated neuron.

65. A method as claimed in claim 64, wherein the sum includes one or more selected from the group consisting of: a memory trace, a combination of the experience of the initiating neuron and the associated neuron, a memory, and a sequence of events.

66. A method as claimed in any one of claims 59 to 65, wherein once the linking neuron is activated to represent a desired result, the desired result need not be recreated in another neuron.

67. A method of operating a neural network having a plurality of neurons including a plurality of elemental neurons and a plurality of structural neurons, the method including the steps:

(a) defining events the elemental neurons and structural neurons will represent;

(b) create a required number of elemental neurons for the total number of unique values to be represented for all defined events; and

(c) create a set rules for association of the plurality of neurons.

68. A method as claimed in claim 67, wherein any one of the plurality of neurons is able to associate with another neuron in the plurality of neurons via active connections to a further neuron in the plurality of neurons.

69. A method as claimed in claim 68, where the further neuron is in a deeper level than both the neuron and the another neuron.

70. A method as claimed in claim 68 or claim 69, wherein the neuron and the another neuron are in the same level.

71. A method network as claimed in claim 68 or claim 69, wherein the neuron and the another neuron are on different levels.

72. A method network as claimed in any one of claims 67 to 71, wherein all elemental and structural neurons are able to express the neurons with which they are associated.

73. A method as claimed in claim 72, wherein associations may be one or more selected from the group consisting of: an elemental neuron with an elemental neuron, an elemental neuron with a structural neuron, a structural neuron with an elemental neuron, a structural neuron with a structural neuron.

74. A method as claimed in any one of claims 67 to 73, wherein each of the plurality of neurons may be one or more selected from the group consisting of: initiating neuron, associating neuron, and linking neuron.

75. A method as claimed in claim 74, wherein an initiating neuron is associated with an associated neuron via active connections to the linking neuron.

76. A method as claimed in claim 75, wherein the initiating neuron, the associated neuron and the linking neuron are connected based on proximal characteristics.

77. A method as claimed in claim 76, wherein the proximal characteristics are at least one of: temporal and spatial.

78. A method as claimed in any one of claims 69 to 77, wherein a level of the neural network is a deeper level within the neural network structure if, during recollection, more steps are required to express the elemental neurons.

79. A method as claimed in any one of claims 74 to 77, wherein:
   (a) firing the initiating neuron potentiates the linking neuron; and
   (b) firing the associated neuron re-potentiates and activates the linking neuron, the linking neuron being able to fire when reactivated.

80. A method as claimed in claim 79, wherein the associated neuron fires at the same time as the initiating neuron.

81. A method as claimed in claim 79, wherein the associated neuron fires after the initiating neuron.

82. A method as claimed in any one of claims 79 to 81, wherein the firing of the initiating neuron and the firing of the associated neuron is based on proximal characteristics.

83. A method as claimed in claim 82, wherein the proximal firing of the initiating neuron and the associated neuron causes the creation of new synaptic connections, or the strengthening of existing synaptic connections, between the initiating neuron and the linking neuron and between the associated neuron and the linking neuron.

84. A method as claimed in any one of claims 79 to 83, wherein the linking neuron represents the sum of what is learnt from the initiating neuron and the associated neuron.

85. A method as claimed in claim 84, wherein the sum includes one or more selected from the group consisting of: a memory trace, a combination of the experience of the initiating neuron and the associated neuron, a memory, and a sequence of events.

86. A method as claimed in any one of claims 69 to 85, wherein the plurality of elemental neurons are represented in a root level of the neural network, and each elemental neuron responds to an elemental stimulus or pattern, each elemental stimulus being for representing one of: a basic input stimuli and an output stimuli of information being processed.

87. A method as claimed in claim 86, wherein the information is memory.

88. A method as claimed in claim 86 or claim 87, wherein the processing is expression.

89. A method as claimed in any one of claims 86 to 88, wherein the plurality of structural neurons are represented in a plurality of deeper neural levels.

90. A method as claimed in claim 89, wherein the number of levels in the plurality of deeper levels is determined by the extent of the memory or pattern to be processed or expressed, where a memory represents a plurality of elemental

stimuli, and each elemental stimulus is represented directly by an elemental neuron.

91. A method as claimed in claim 90, wherein the number of elemental neurons required to represent the memory is determined by a nature of the memory to be processed.

92. A method as claimed in any one of claims 67 to 91, wherein each neuron is represented in its entirety by a single, fixed-length node in an array.

93. A method as claimed in any one of claims 67 to 92, wherein each of the plurality of neurons is in an array, there being pointers in the array for providing expression.

94. A method as claimed in claim 93, wherein each neuron is represented by a node in the array, each node having a plurality of pointers, each pointer in each node containing an exclusive address of another neuron.

95. A method as claimed in any one of claims 67 to 94, wherein all neurons are of a fixed length and do not have a variable length.

96. A computer usable medium comprising a computer program code configured to cause one or more processors to execute one or more functions to perform the method claimed in claims 67 to 95.

ABSTRACT

Neural Networks with Learning Capability

A neural network for implementing intelligent learning, expression, behaviour and creativity using a multi dimensional neural network based on temporal and/or spatial characteristics.

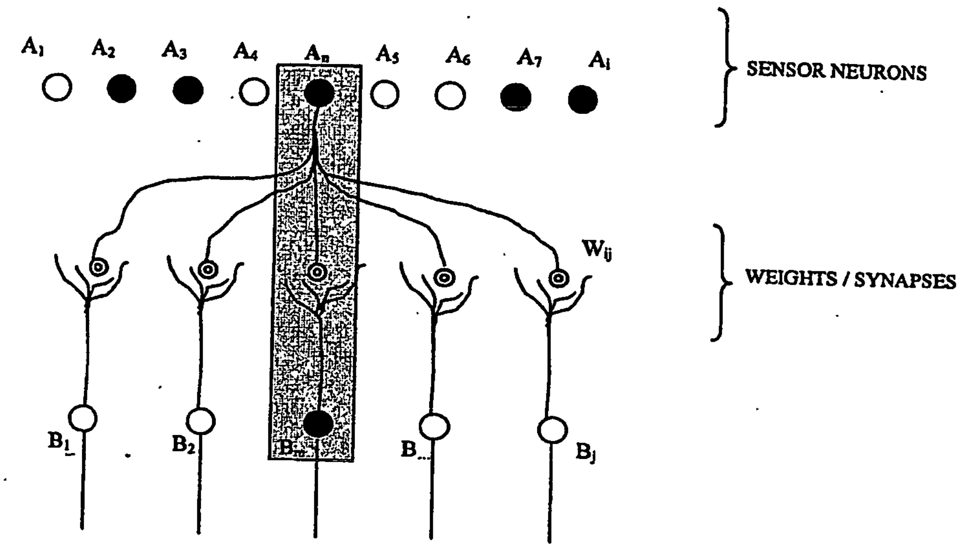


Figure 1

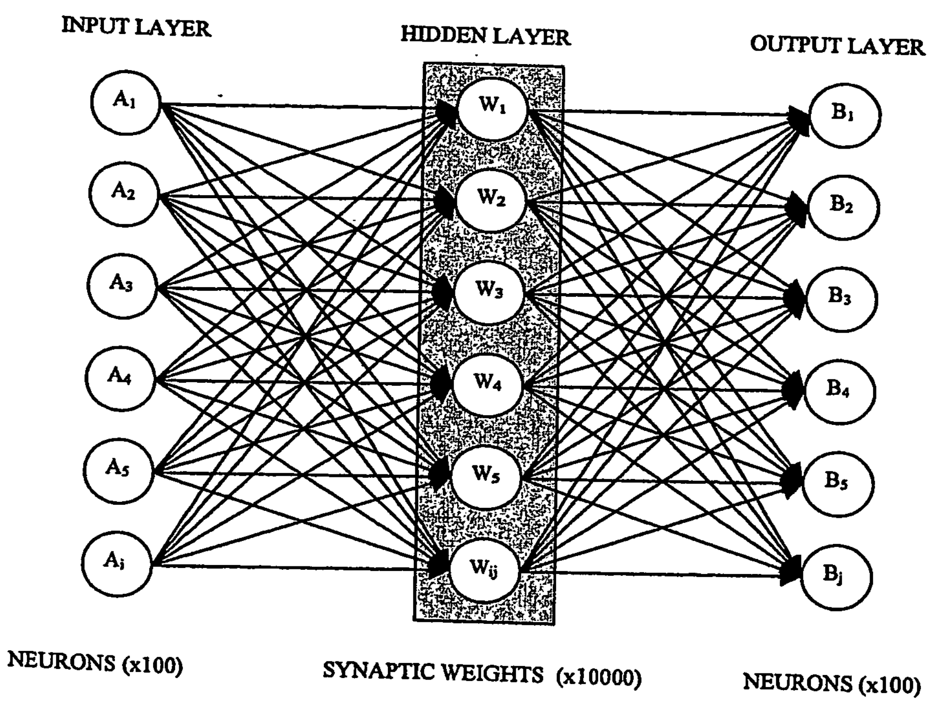


Figure 2

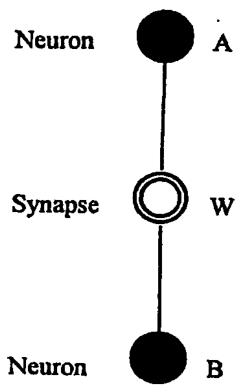


Figure 3

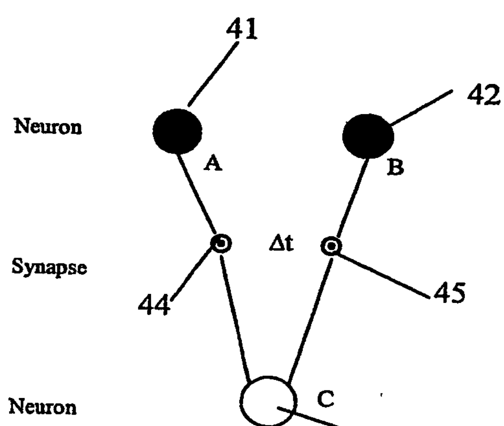


Figure 4

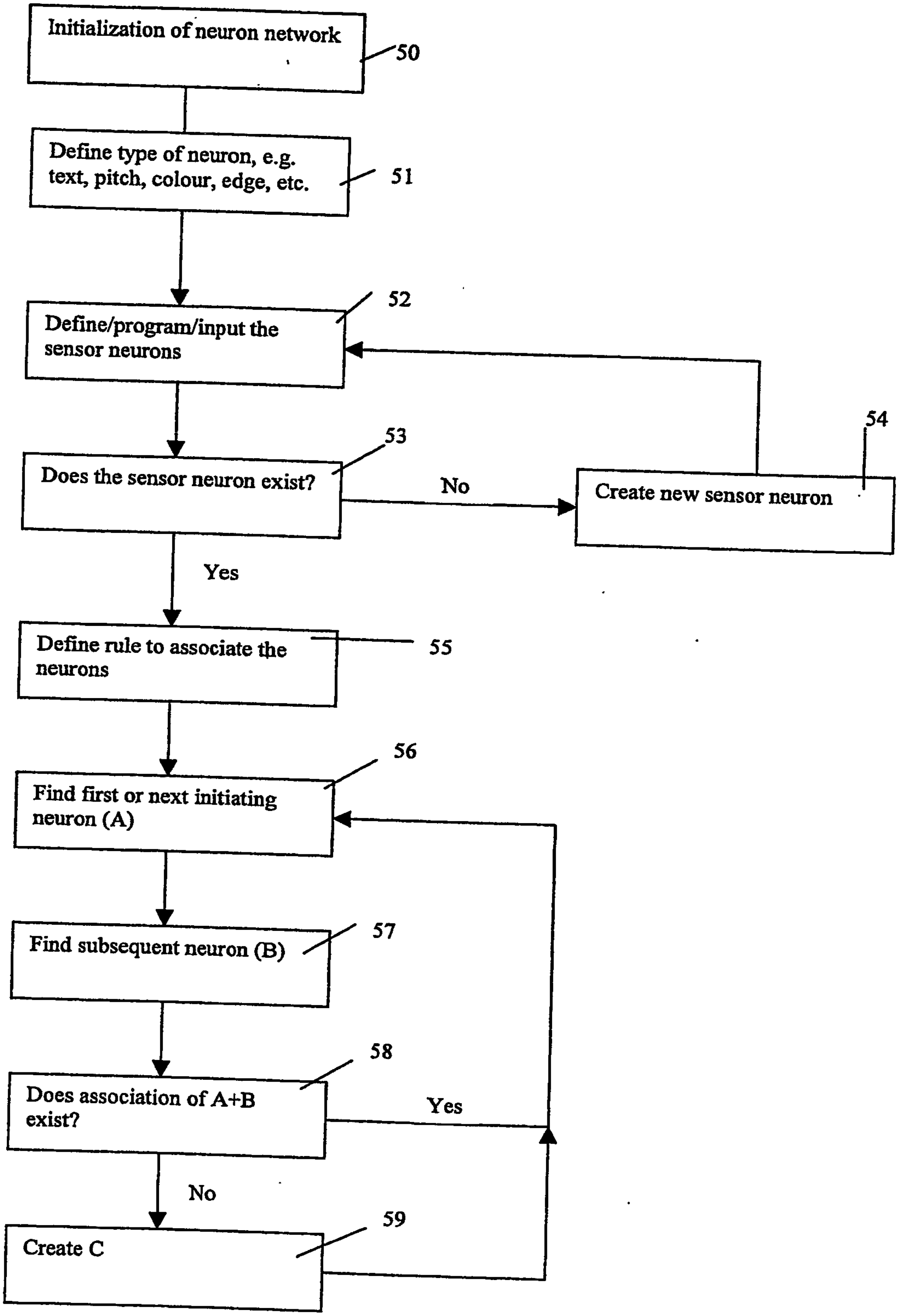

Initialization of neuron network
50
Define type of neuron, e.g. text, pitch, colour, edge, etc.
51
52
Define/program/input the sensor neurons
53
Does the sensor neuron exist?
No
54
Create new sensor neuron
Yes
Define rule to associate the neurons
55
56
Find first or next initiating neuron (A)
57
Find subsequent neuron (B)
58
Does association of A+B exist?
Yes
No
59
Create C

Figure 5

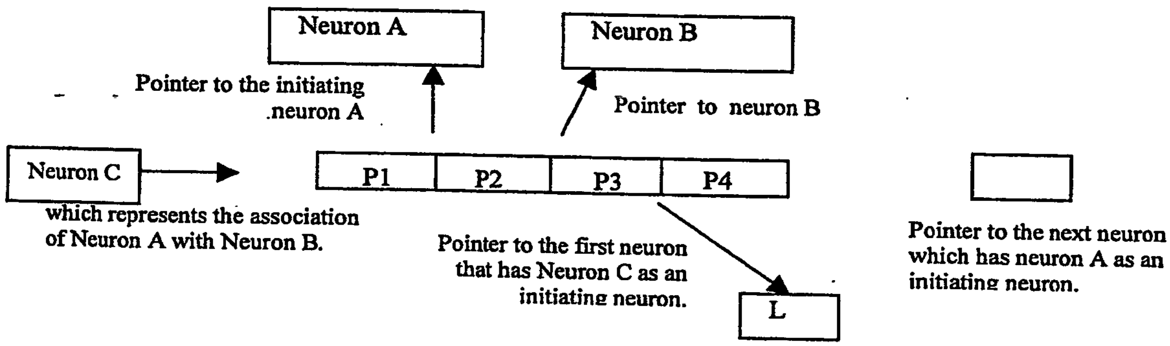

Neuron A
Neuron B
Pointer to the initiating .neuron A
Pointer to neuron B
Neuron C
P1
P2
P3
P4
which represents the association of Neuron A with Neuron B.
Pointer to the first neuron that has Neuron C as an initiating neuron.
L
Pointer to the next neuron which has neuron A as an initiating neuron.

Figure 6

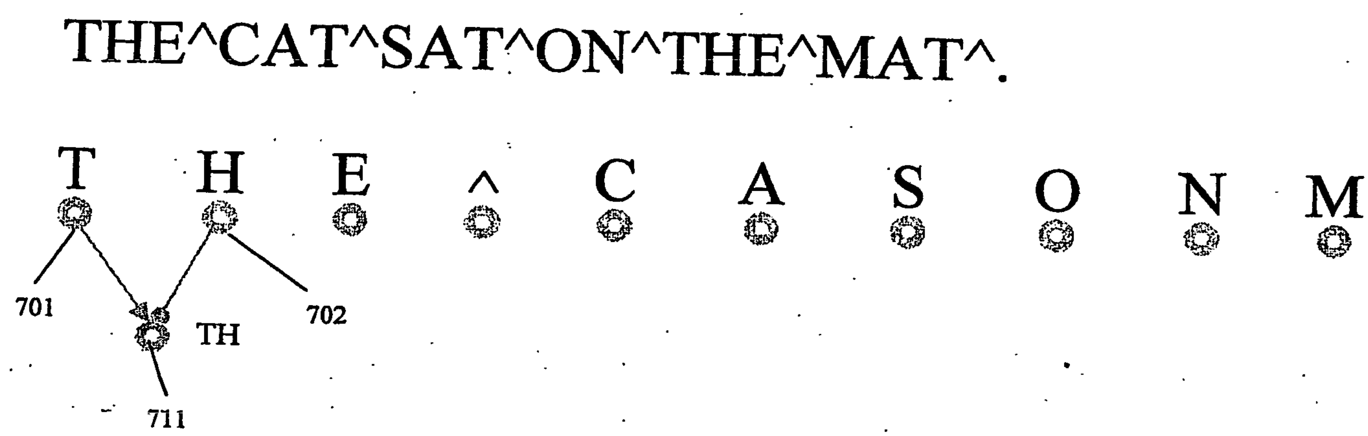


Figure 7(a)

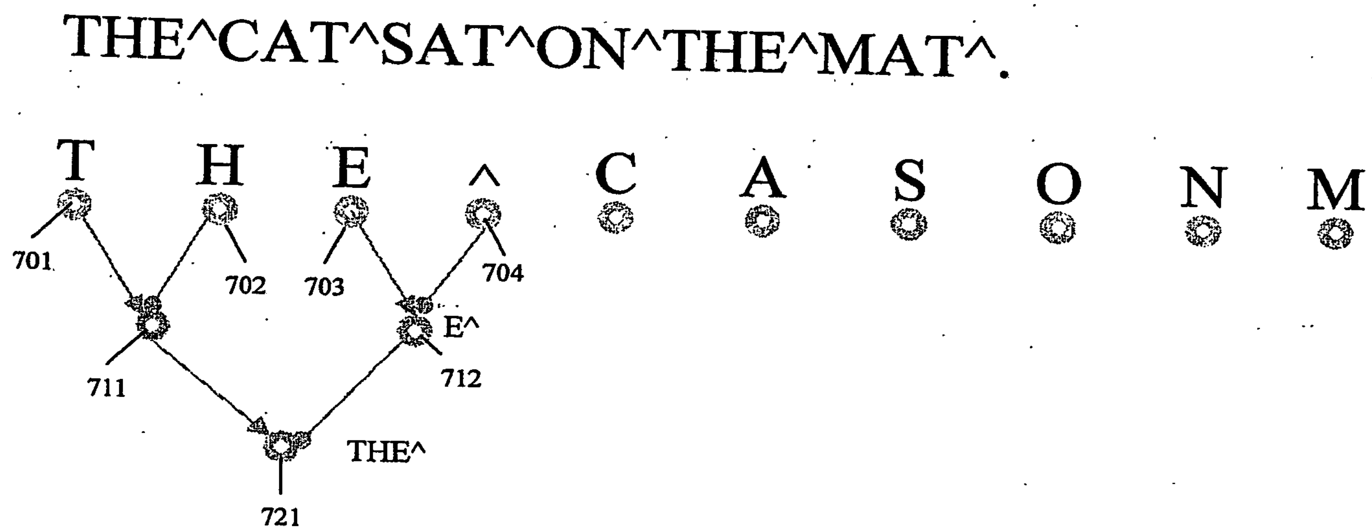


Figure 7(b)

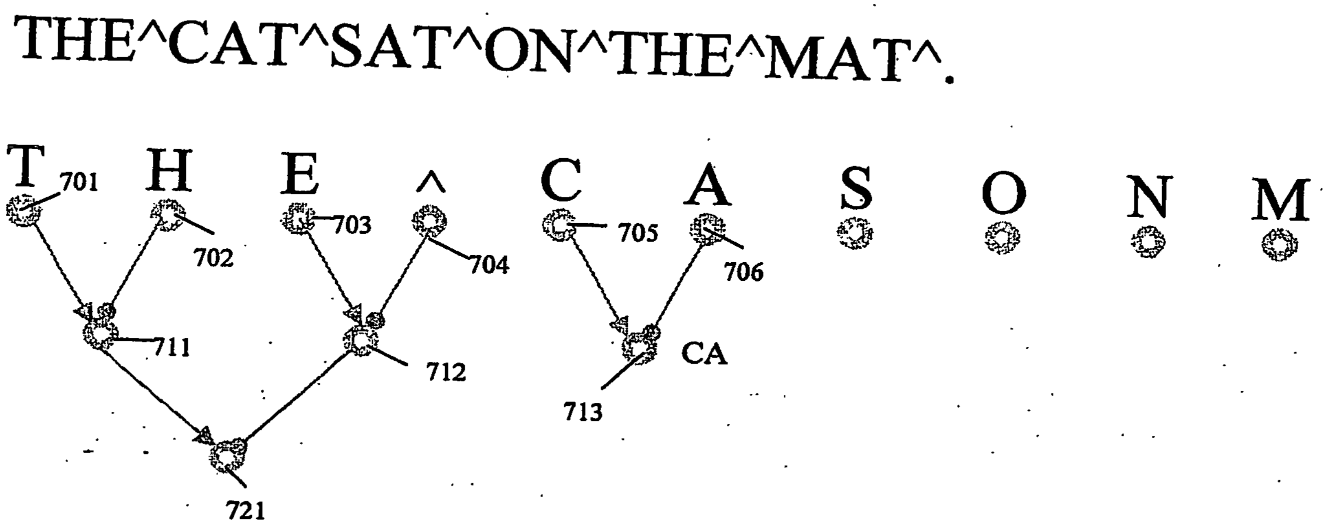


Figure 7(c)

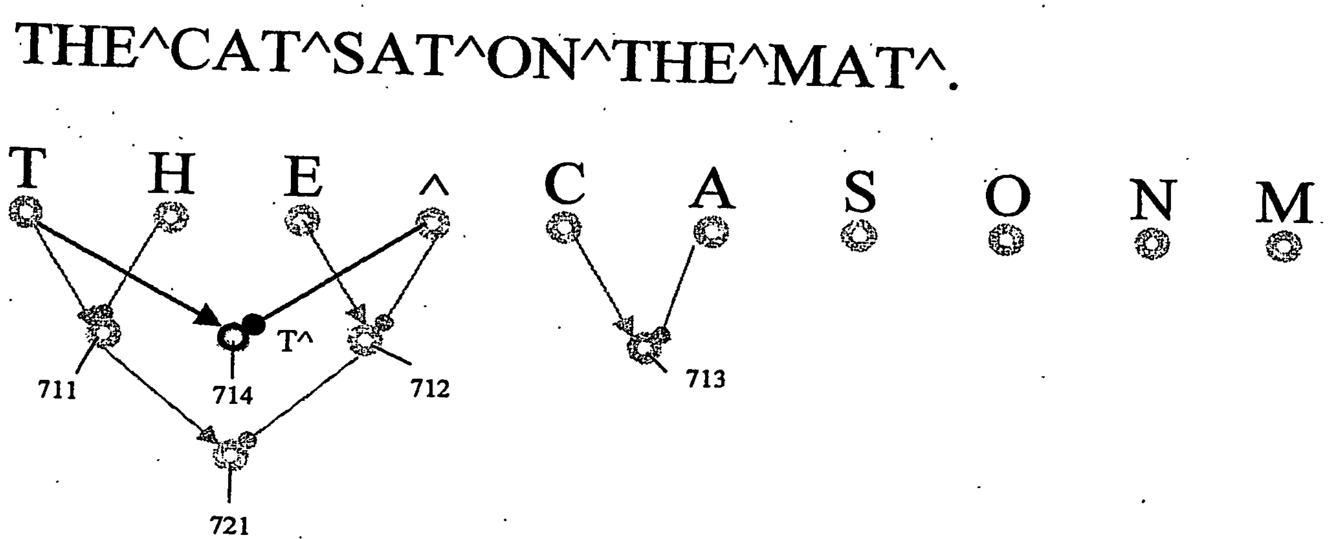


Figure 7(d)

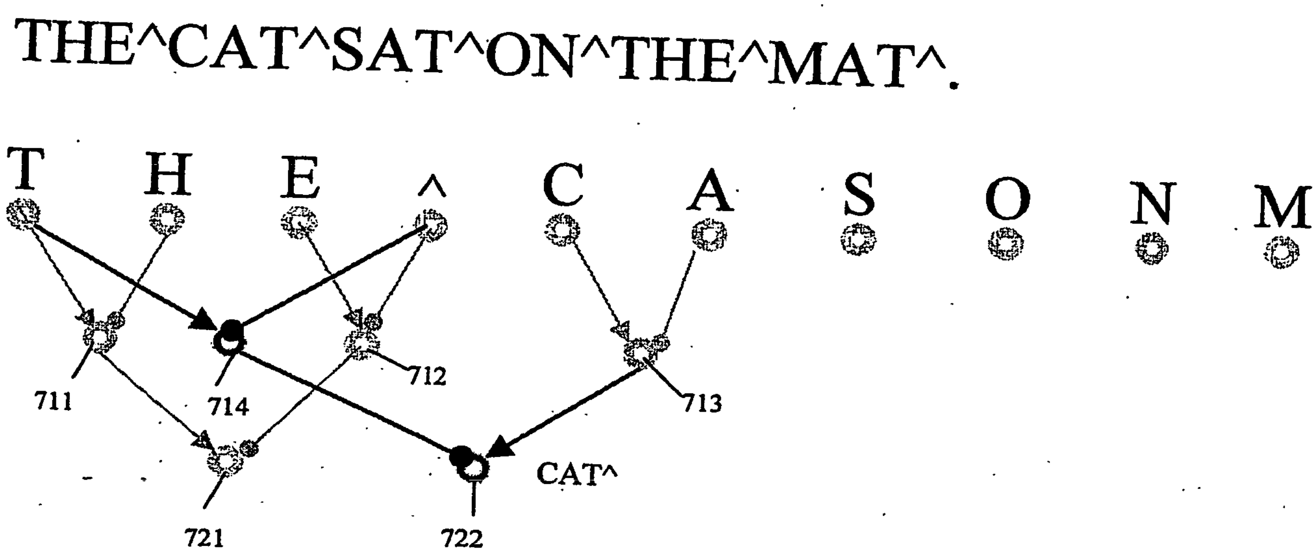


Figure 7(e)

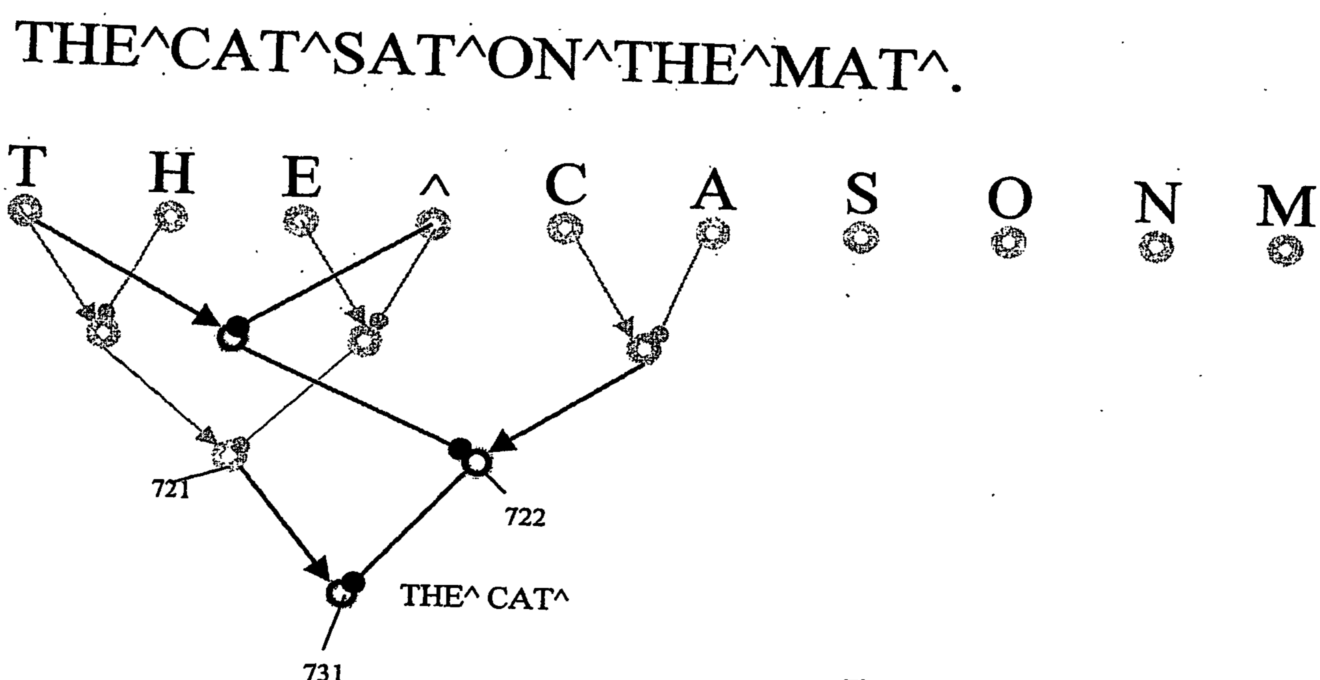


Figure 7(f)

THE^CAT^SAT^ON^THE^MAT^.

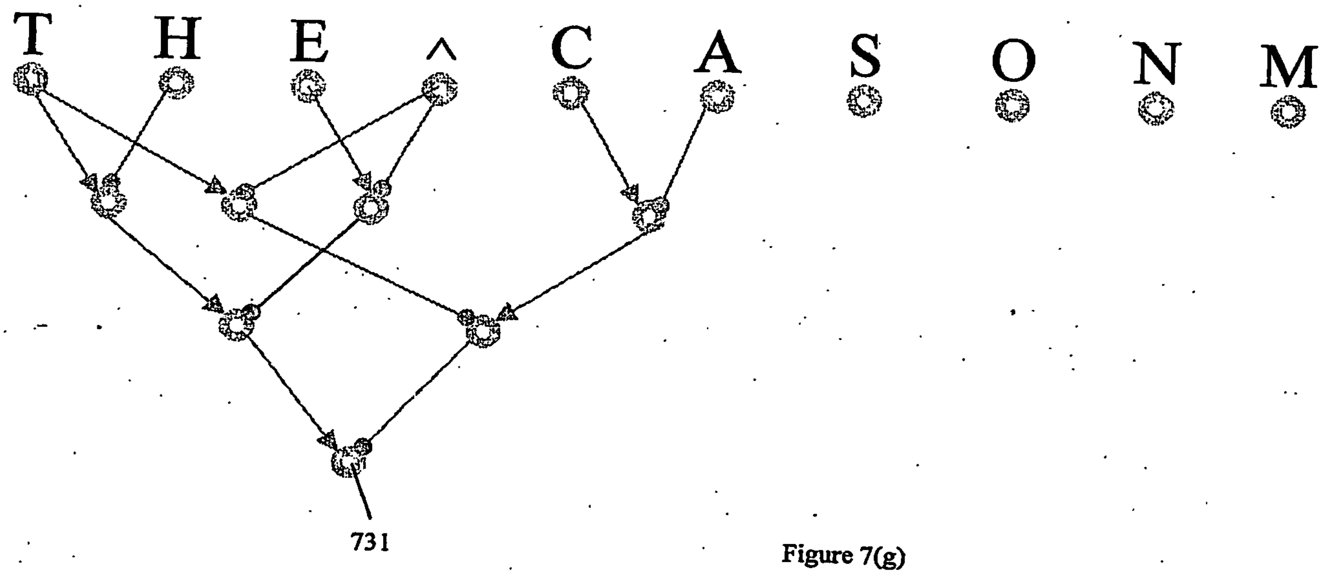


Figure 7(g)

THE^CAT^SAT^ON^THE^MAT^.

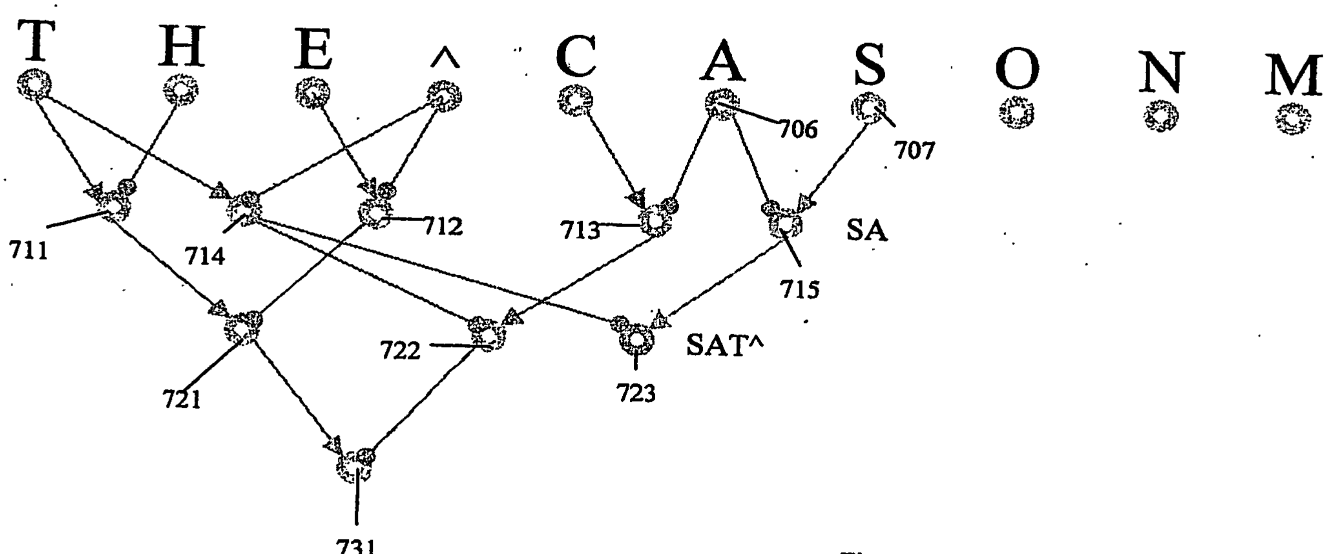


Figure 7(h)

THE^CAT^SAT^ON^THE^MAT^.

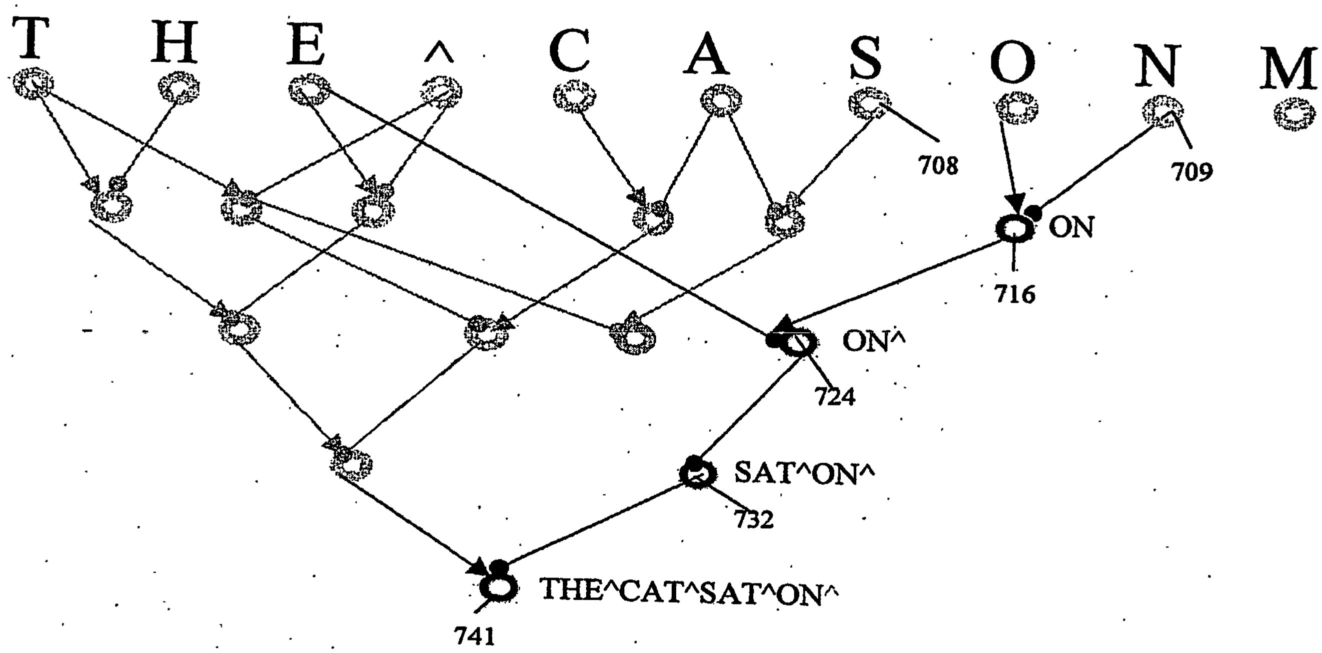


Figure 7(i)

THE^CAT^SAT^ON^THE^MAT^.

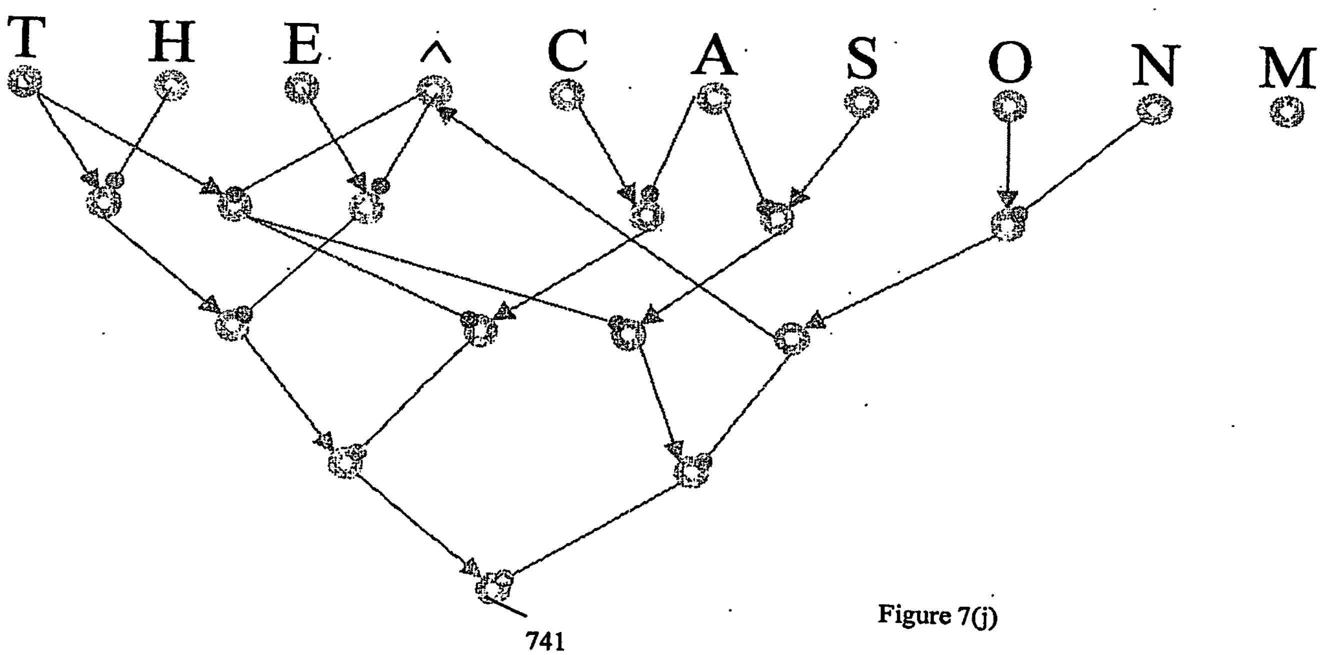


Figure 7(j)

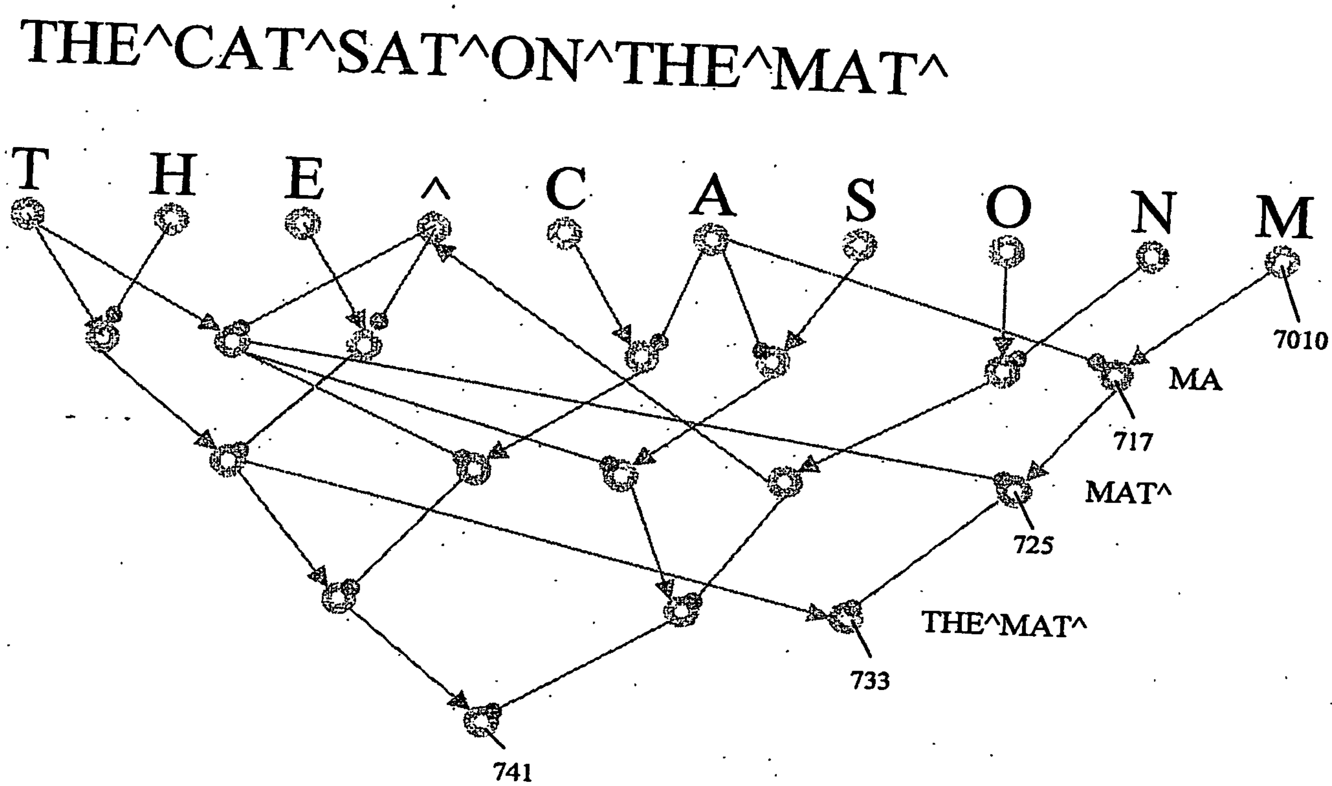


Figure 7(k)

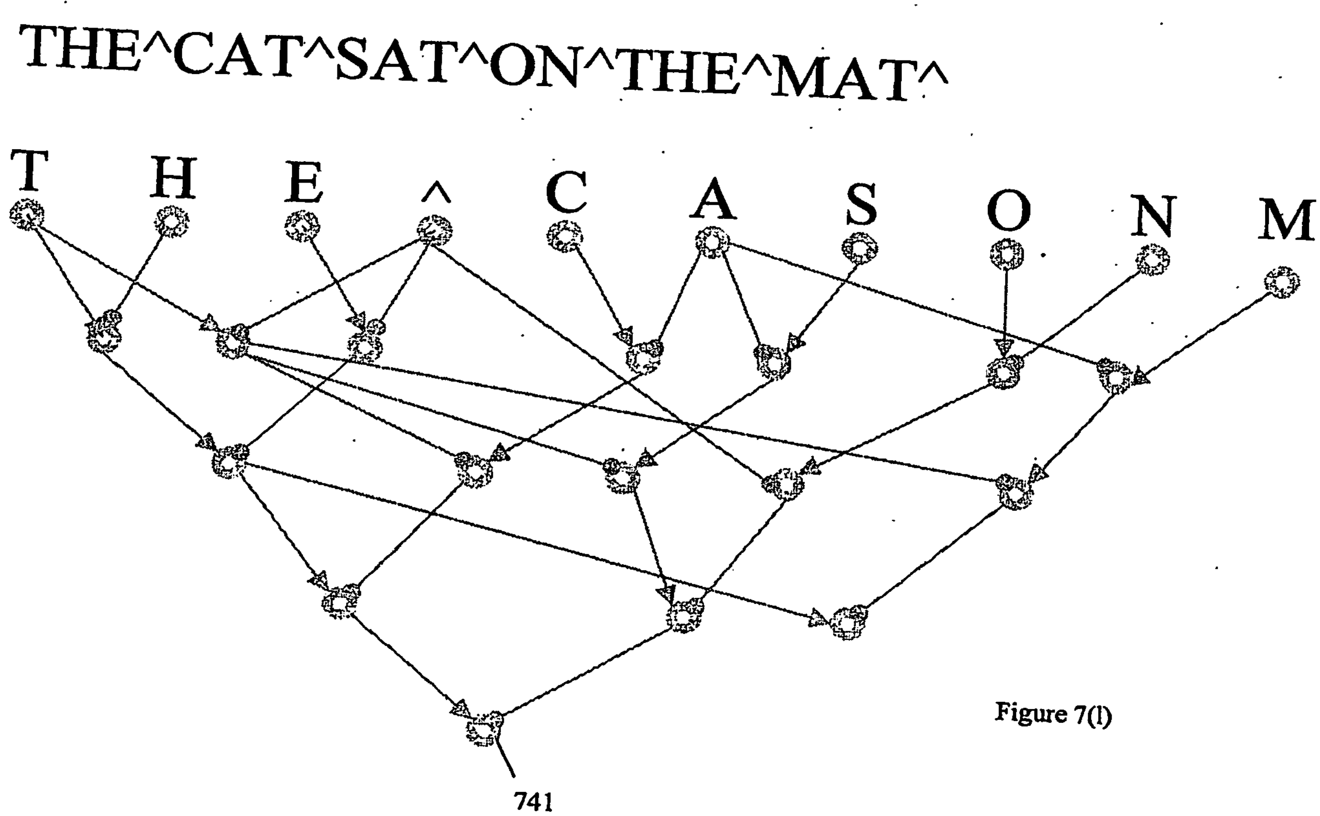


Figure 7(l)

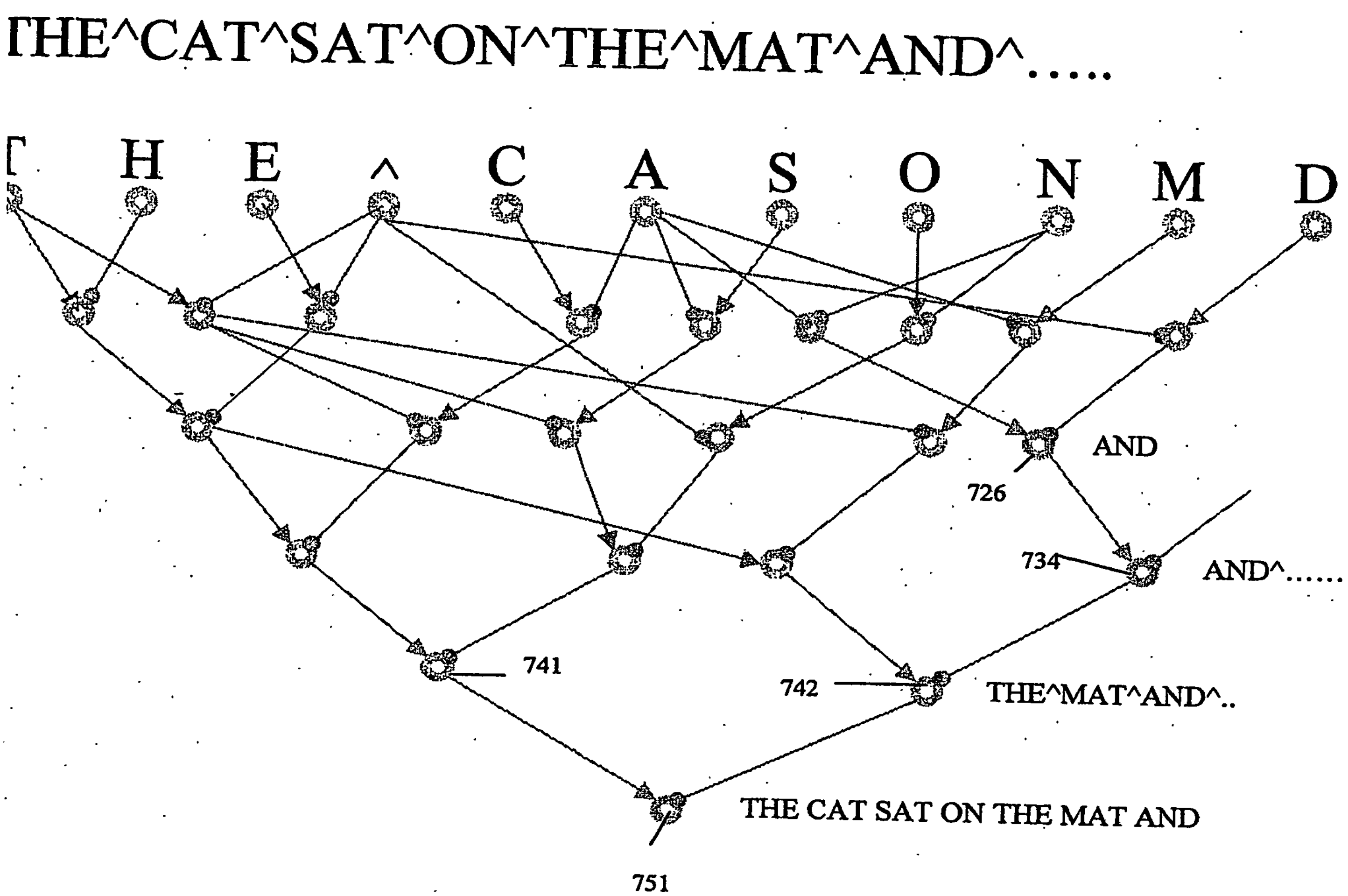

ΓHE^CAT^SAT^ON^THE^MAT^AND^.....
Γ H E ^ C A S O N M D
AND
726
734
AND^......
741
742
THE^MAT^AND^..
THE CAT SAT ON THE MAT AND
751

Figure 7(m)

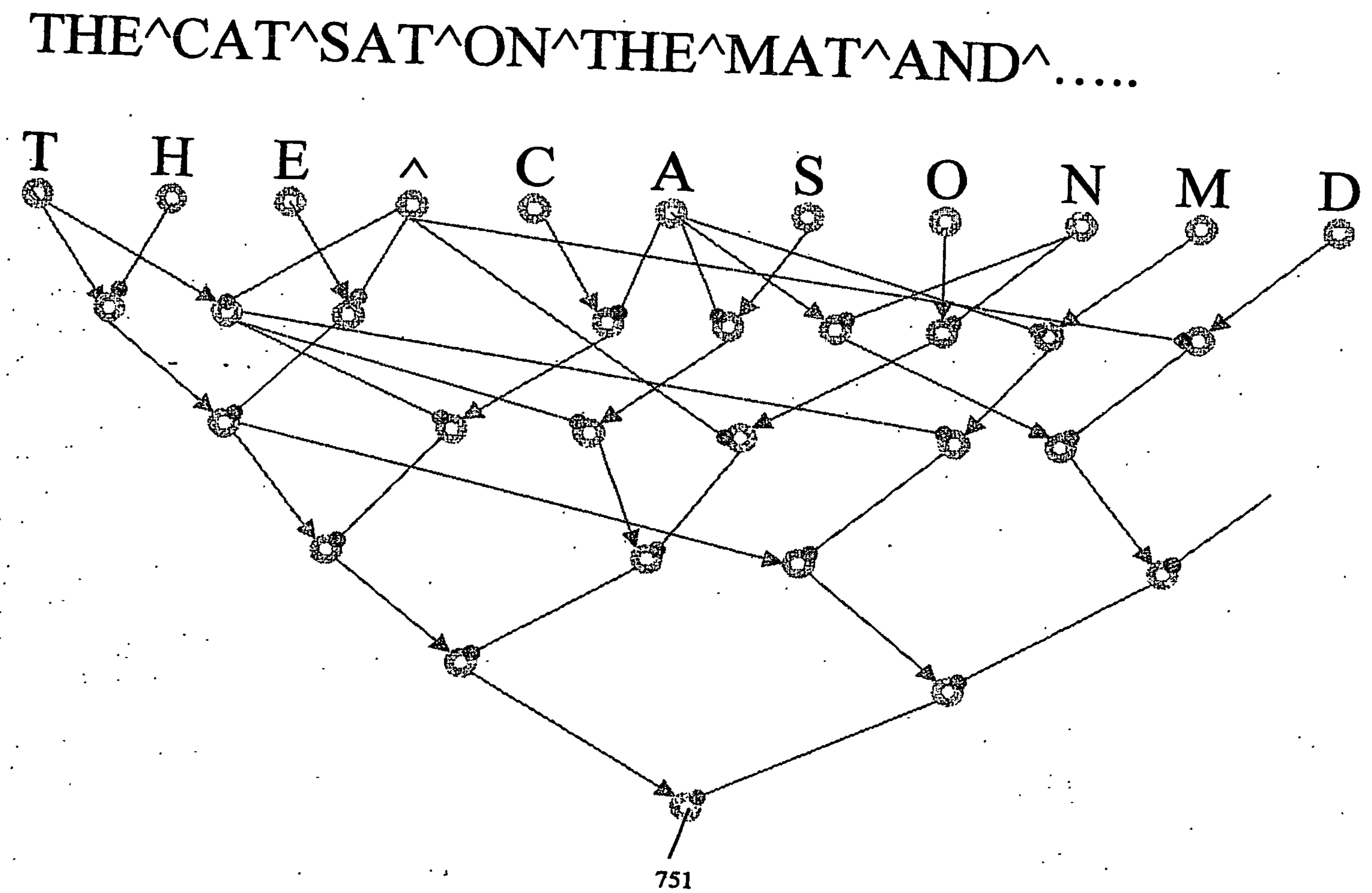
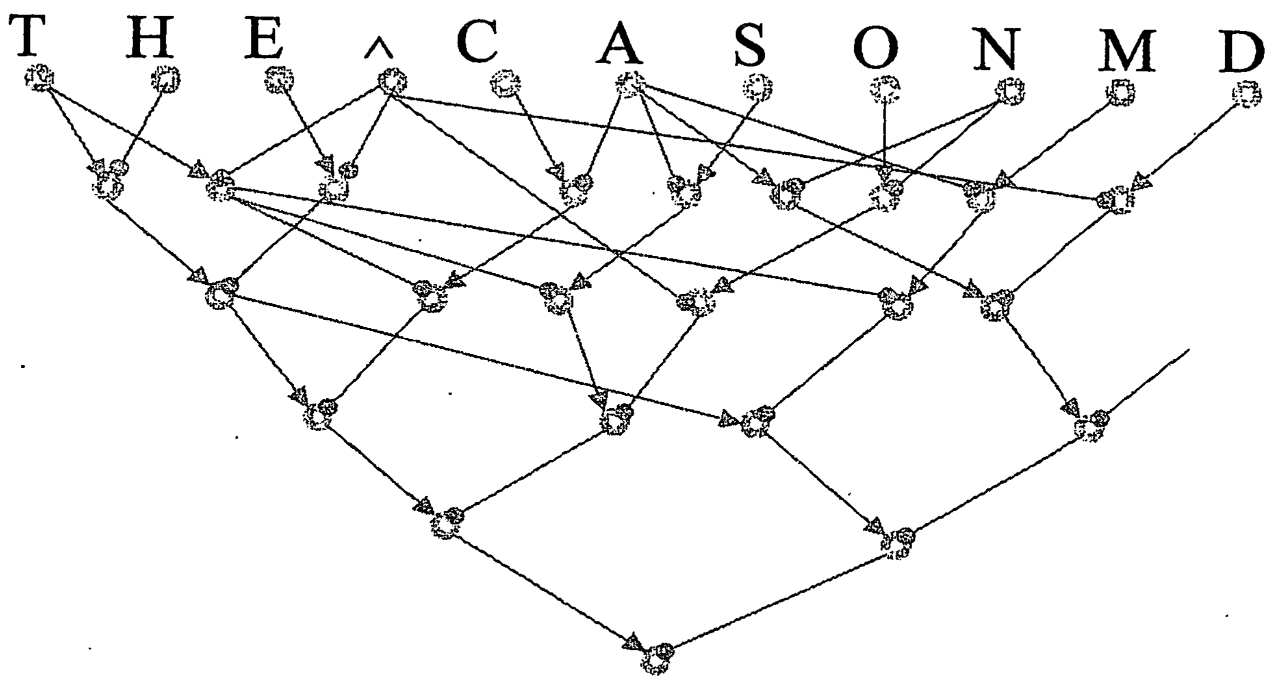


Figure 7(n)

THE^CAT^SAT^ON^THE^MAT^AND^.....(27..chars)



vel.	# chars
0	1
1	2
2	4
3	8
4	16
5	32
.	
.	
10	1,024 chars
.	
.	
20	1,048,576 chars

Figure 7(o)

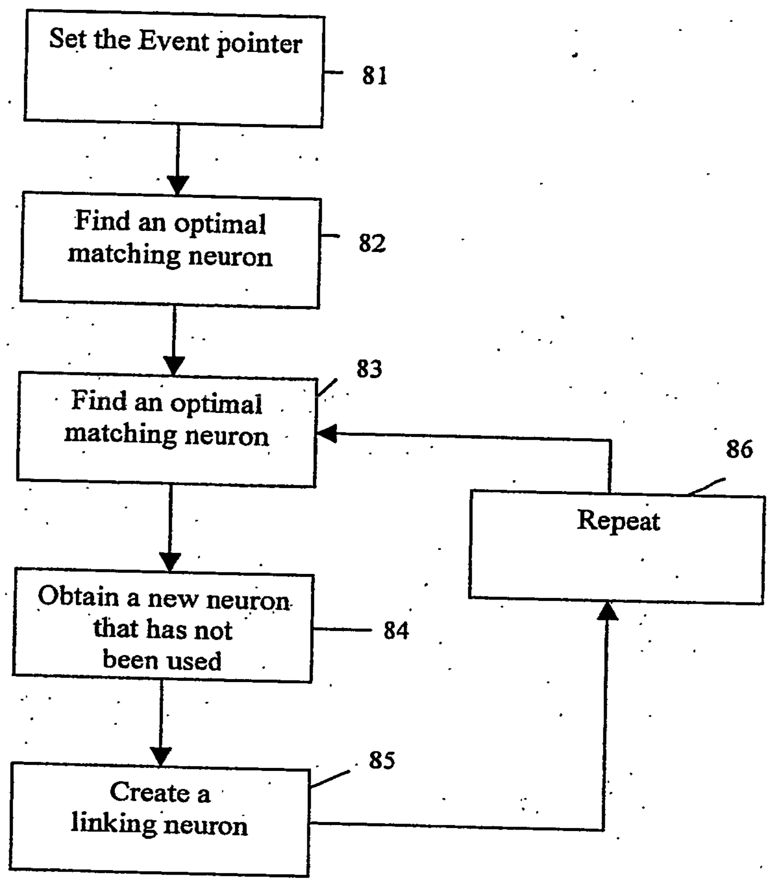

Set the Event pointer
81
Find an optimal matching neuron
82
Find an optimal matching neuron
83
Repeat
86
Obtain a new neuron that has not been used
84
Create a linking neuron
85

Figure 8

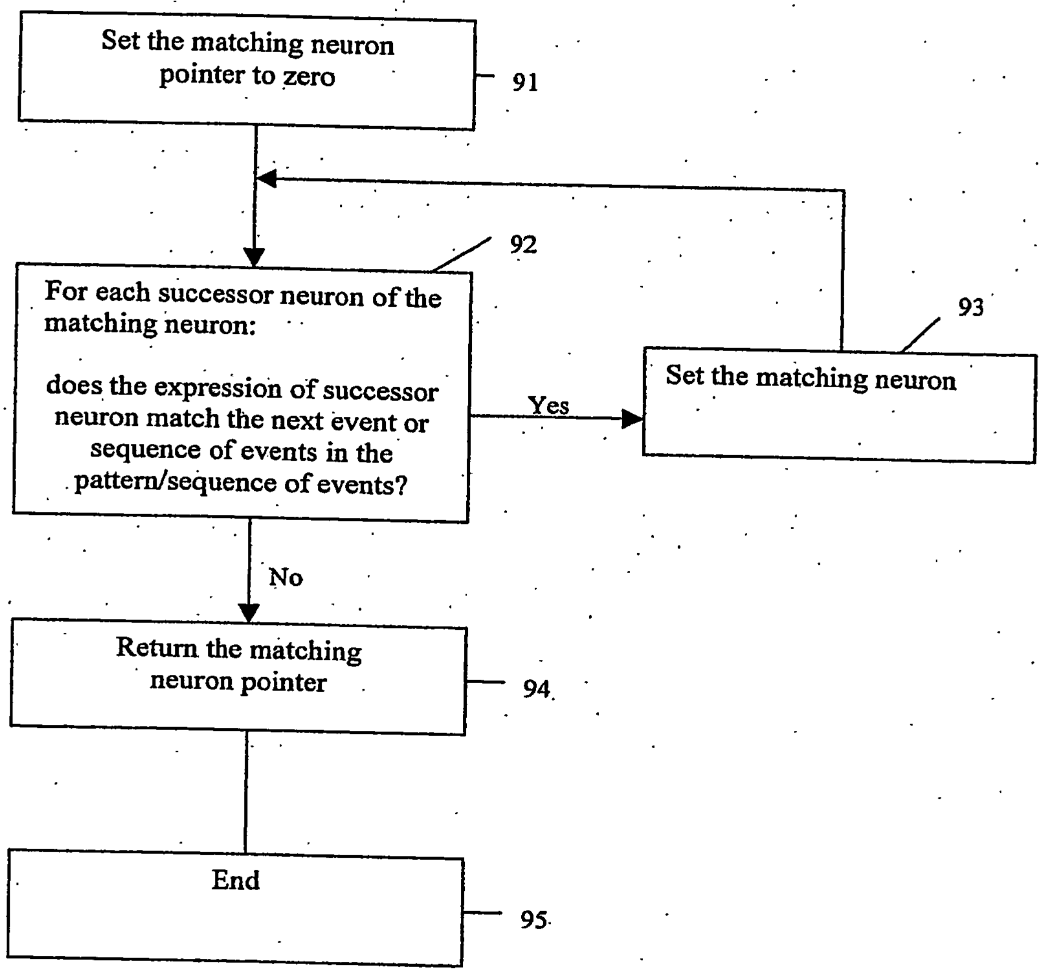


Figure 9

20032400 26 JUN 2003

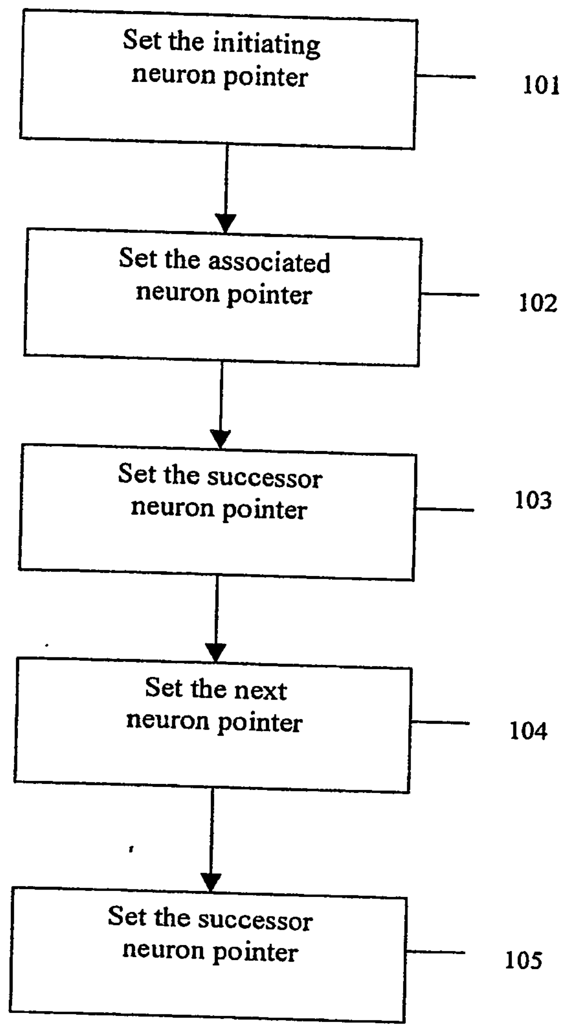

Set the initiating neuron pointer
101
Set the associated neuron pointer
102
Set the successor neuron pointer
103
Set the next neuron pointer
104
Set the successor neuron pointer
105

Figure 10

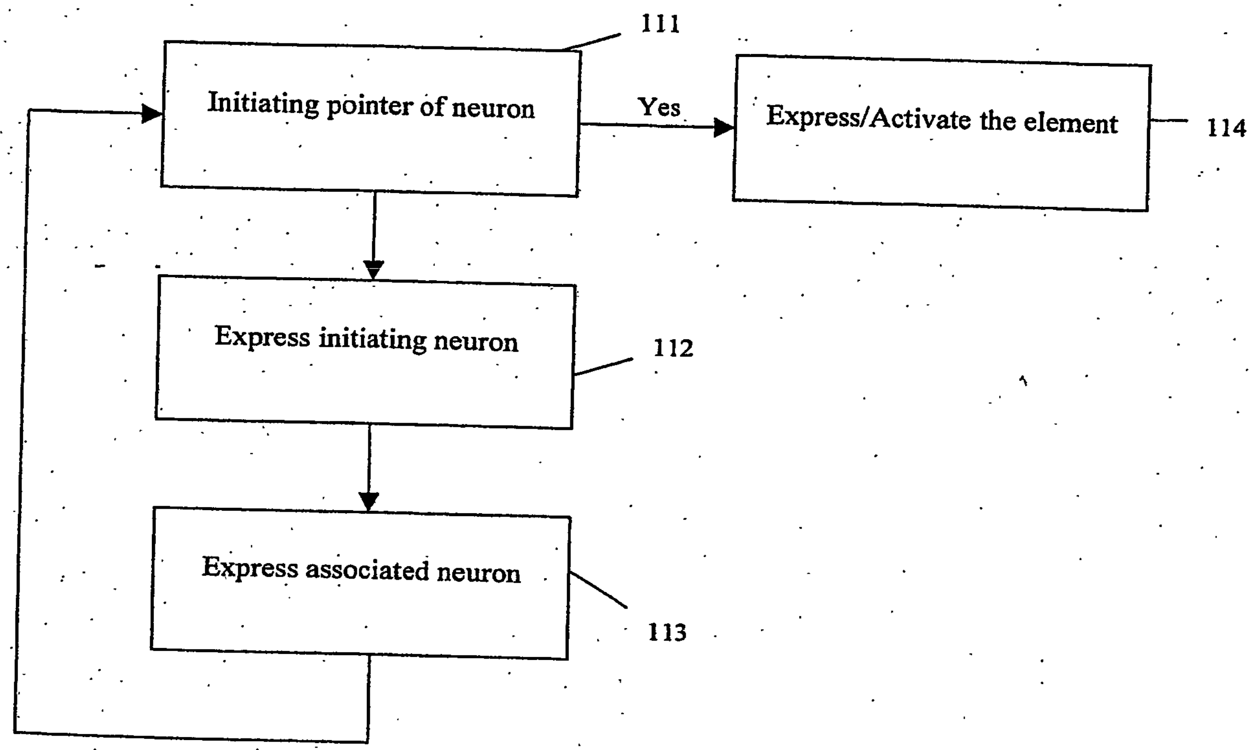

111
Initiating pointer of neuron
Yes
Express/Activate the element
114
Express initiating neuron
112
Express associated neuron
113

Figure 11